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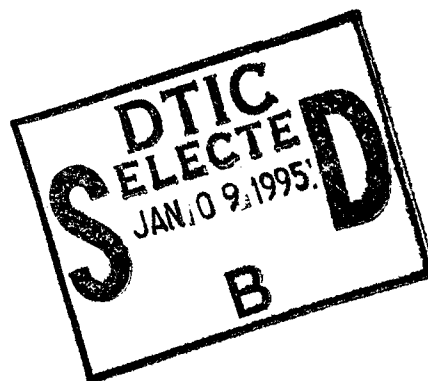
The Department of Defense Central Heating Plant Operator Training and Certification Program: An Overview

by

Michael K. Brewer and Ralph E. Moshage

The variety of equipment found in Department of Defense (DOD) central energy plants (CEPs) and the complexity of these plants demands that CEP operators be highly qualified personnel. Given the serious danger posed by improperly operated boilers, similar operations in the private sector have long maintained processes to establish credentials for their employees. The 1990 Clean Air Act Amendments (CAAA 1990) also recognize the importance of trained and certified fuel plant operators toward improving air quality. As a result of CAAA 1990, the U.S. Environmental Protection Agency (USEPA) will eventually require all operators of boilers with capacities greater than 10 million BTU per hour (298 Boiler HP) to be trained and certified.

A DOD-wide training and certification program for CEP operators needs to be developed and implemented to increase the safety and reduce the energy and environmental cost of operating central energy plants, and to meet the CAAA 1990 requirements. This study examined the training needs of central energy plant operators at DOD installations to identify the resources required to meet those needs and to assess their effectiveness in the field.



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Executive Summary

The variety of equipment found in Department of Defense (DOD) central energy plants (CEPs) and the complexity of these plants demands that CEP operators be highly qualified personnel. Given the serious danger posed by improperly operated boilers, similar operations in the private sector have long maintained processes to establish credentials for their employees. The 1990 Clean Air Act Amendments (CAAA; Public Law [PL] 101-549, 104 stat 2399) also recognize the importance of trained and certified fuel plant operators toward improving air quality. As a result of the CAAA 1990, the U.S. Environmental Protection Agency (USEPA) may eventually require all operators of boilers with capacities greater than 10 million BTU per hour (298 Boiler HP) to be trained and certified. The U.S. Environmental Protection Agency (USEPA) has been tasked by the CAAA 1990 to develop model training and certification programs for the operators of high-capacity fossil fuel plants, which may eventually be applied to DOD installations.

The DOD operates nearly 100 installations in 12 jurisdictions that currently have boiler operator licensing requirements in the interest of public safety. Since it is one of the largest operators of CEPs in the United States, it is in the DOD's interest to minimize the impact of operating these plants on the environment, both locally and nationally. The downsizing of the DOD and accompanying reduction in available operating resources in both personnel and money has given the DOD an interest in proactively working to meet the intent of the CAAA and to help the USEPA develop a model training and certification standard. Such an effort would further prepare the DOD to operate its plants with fewer personnel and lower fuel costs to free resources for higher priority programs.

A DOD-wide training and certification program for CEP operators needs to be developed and implemented to increase the safety and reduce the energy and environmental cost of operating central energy plants, and to meet the CAAA 1990 requirements. This study examined the training needs of central energy plant operators at DOD installations to identify the resources required to meet those needs and to assess their effectiveness in the field.

A committee was formed to develop a strategy to implement boiler operator training and certification standards in the DOD. This working group formulated the approach for a pilot program, the primary strategy of which was to use existing

the approach for a pilot program, the primary strategy of which was to use existing industry accepted standards and products to meet the assessed training and certification needs of DOD boiler operators. The Office of Personnel Management (OPM) and several DOD personnel offices were contacted to investigate the mechanisms for implementing a boiler operator certification program.

A sample training course was designed and given at various DOD installations. Course effectiveness was evaluated by administering and comparing the results from pre- and post-tests, and from a a National Institute for the Uniform Licensing of Power Engineers (NIULPE) standard examination. It was found that the students showed marked improvement at the end of the pilot program.

The study recommended that the NIULPE examination standard tentatively be used as a qualification standard for operators of DOD central heating plants until it is clear that the USEPA standard will not disqualify the use of the NIULPE certification to meet the intent of the CAAA 1990. The study also recommended that all operators of DOD central heating plants be minimally required to have a NIULPE Fourth Class Power Engineer license (by examination). This training is currently available through the U.S. Army Center for Public Works (USACPW), which, based on the recommendations of the DOD study group, has put a contract in place to provide NIULPE 4th class training and certification. The study also recommends specific training tools, including a continuing education program and study materials that can help operators meet and maintain the recommended job qualifications. Materials include currently available textbook and library materials, videotapes, and workshops, as well as a proposed interactive, computer-based training/testing program.

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Foreword

This study was conducted for the U.S. Army Center for Public Works (USACPW), and Headquarters, U.S. Army Training and Doctrine Command (TRADOC), and the Naval Facilities Engineering Service Center (NFESC) under Project 4A162-784AT45, "Energy and Energy Conservation"; Work Unit EB-XK3, "Central Energy Supply: Advanced Operations and Maintenance," and Military Interdepartmental Purchase Request (MIPR) No. E87420477 and N0002593MP006M. The technical monitors were Qaiser Toor, DAIM-FDF-U; Dennis Vevang, CECPW-EM; Conrad Browe, HQ-TRADOC-ATBO-GFE; and A. Henry Studebaker, NFESC Code 241.

The work was performed by the Energy and Utility Systems Division (FE) of the Infrastructure Laboratory (FL), U.S. Army Construction Engineering Research Laboratories (USACERL). Donald Fournier is Acting Chief, CECER-FE, and Dr. David Joncich is Acting Chief, CECER-FL. The USACERL principal investigator was Ralph E. Moshage. Special appreciation is expressed to the public works staffs at Fort Eustis, VA, Fort Knox, KY, Fort Benning, GA, Fort Lee, VA, Picatinney Arsenal, NJ, Norfolk Naval Station, VA, Camp Pendleton, CA, and Puget Sound Naval Shipyard, Bremerton, WA for their participation in the pilot programs. Thanks is owed to Qaiser Toor, SFIM-IS-FP-U, and Henry Studebaker, NFESC, for their assistance and guidance throughout the project. The USACERL technical editor was William J. Wolfe, Information Management Office.

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Distribution

1 Introduction

Background

Legal Requirements

The variety of equipment found in typical Department of Defense (DOD) central energy plants (CEPs) and the complexity of the overall operation and maintenance of these plants demands that plant operators be highly qualified personnel. Army Regulation (AR) 420-15 requires that "all utility plant supervisors (e.g., foreman), [and] operators . . . will be properly certified."* In addition to requiring operator certification, the regulation stipulates that mechanisms be made available to give personnel the opportunity to acquire the required skills, specifically that "formal and/or informal training programs will be established for those employees requiring additional training to upgrade their skills, to qualify them for certification, and to provide for their career development." Additionally, AR 420-15 encourages that "Advantage should be taken of existing training programs within the Department of Defense (DOD), Department of the Army, industry, and Federal or State Governmental agencies." Specific details for carrying out these training and certification requirements are the responsibility of the major commands of each service branch.

The Air Force has recognized this need for standards in Air Force Manual 85-12 Volume 1 (AFM 85-12 Vol. 1), which states that, "It is highly desirable that plant supervisors and operators be licensed; it is mandatory that they be qualified by training and experience to operate and maintain equipment properly and efficiently. Personnel should be encouraged to obtain licenses and to participate in local training schools, Air Force training programs and self-study." Additionally, AFM 85-12 Vol. 1 paragraph 88 and Air Force Regulation 91-7 (AFR 91-7) stipulates that there must be a training and certification mechanism managed by the base engineer to fulfill the requirement that only qualified personnel operate plant equipment.

* Army Regulation (AR) 420-15, *Certification of Utility Plant Operators and Personnel Performing Inspection and Testing of Vertical Lift Devices* (Headquarters, U.S. Army Corps of Engineers [HQUSACE], 03 June 1975).

Environmental Impact, Energy Efficiency, and Safety

Given the complex nature of boiler systems and the serious danger posed by improperly operated boilers, the heating and power industry in the private sector has long maintained a licensing or certification process to establish minimum credentials for their employees. Additionally, the 1990 Clean Air Act Amendments (Public Law [PL] 101-549, 104 stat 2399, hereafter referred to as CAAA 1990, and included in Appendix A to this report) recognize the importance of properly trained and certified operators of high-capacity fossil fuel plant in improving air quality. The U.S. Environmental Protection Agency (USEPA) has been tasked by the CAAA 1990 to develop model training and certification programs for the operators of high-capacity fossil fuel plants, which may eventually be applied to DOD installations. Much of the federal environmental law enforcement has been delegated to the state environmental agencies. Currently certain positions, such as waste treatment plant operators, require state licensing of federal employees where the state is enforcing federal mandates.

The DOD operates nearly 100 installations in 12 jurisdictions that currently have boiler operator licensing requirements in the interest of public safety. Although the federal government has historically held itself immune from many state licensing programs, federal mandates to the state on environmental issues could override that immunity. Additionally, certification has been used in several federal agencies to establish minimum credentials for certain occupations.

Since 1987, the Army, Navy, and Air Force have investigated implementing boiler operator training and certification mechanisms. These investigations have identified the benefits and liabilities of at least three different strategies to implement a training and certification program. The first strategy was to simply use an available state or municipal license. This option was ruled out since it would not give the DOD uniform or fair testing requirements between installations and/or between states. A second option would be to establish a government certification and testing board. This would create a uniform standard, but at high startup and operation costs. The third option was to use the existing National Institute for the Uniform Licensing of Power Engineers (NIULPE) standard, already the standard in the 28 states that have NIULPE chapters. This alternative is in agreement with the U.S. Navy initiative on boiler certification, which indicated that using a nationally recognized, third-party licensing standard seemed to be more advantageous than establishing a new U.S. Navy certification infrastructure or attempting to comply with each jurisdiction's particular standard.

Circumstances have made the development of a qualification standard a pressing issue. USACERL researchers met with representatives from the Naval Facilities

Engineering Service Center (NFESC), the USEPA, and the American Society of Mechanical Engineers (ASME) to obtain the details of the CAAA 1990 training and certification module. ASME is developing a qualification standard expected to be available by late 1996. Meanwhile, the USEPA is under a court order to deliver a model training and certification program to the individual state EPAs by 30 September 1994. The exact content of this program has not been revealed to DOD personnel. However, DOD personnel attended a USEPA-sponsored pilot training course conducted 19-22 April 1994 in Raleigh, NC. The 3½-day course was similar to the NIULPE course in scope in its emphasis on pollution control technology, but it did not match the NIULPE course in coverage of material related to total plant safety, or operation and maintenance.

Since it is one of the largest operators of CEPs in the United States, it is in the DOD's interest to minimize the impact of operating these plants on the environment, both locally and nationally. Additionally, with the downsizing of the DOD and accompanying reduction in available operating resources in both personnel and money, it is also in the interest of the DOD to proactively work to meet the intent of the CAAA and to help the USEPA develop a model training and certification standard. Such an effort would further prepare the DOD to operate its plants with fewer personnel and lower fuel costs to free resources for higher priority programs.

Objective

The overall objective of this study is to identify, develop, and test training methods to provide central heating plant operators with the knowledge and skills necessary for their tasks, and to objectively measure and certify operator competence. The objective of this part of the project was to identify the knowledge and technical skills required to safely and efficiently operate DOD central energy plants.

Approach

A committee was formed to develop a strategy to implement boiler operator training and certification standards in the DOD. Members were drawn from engineering support activities in the Army, Navy and Air Force. This working group formulated the approach for the pilot program in meetings conducted in 1992. The primary strategy of the pilot program was to use existing industry accepted standards and products to meet the assessed training and certification needs of DOD boiler operators. The Office of Personnel Management (OPM) and

several DOD personnel offices were contacted to investigate the mechanisms for implementing a boiler operator certification program.

The skills and knowledge required of boiler operators were independently reviewed. CEP operation and maintenance (O&M) training methods, and the resources and reference materials available in the government and private sector were identified and reviewed, including self-training methods and materials. A literature collection in the library of the National Association of Power Engineers (NAPE) used by that organization to prepare its members for certification was reviewed, and the materials forwarded to the participating DOD installations.

A sample course was designed and given at various DOD installations. Course effectiveness was evaluated by administering a pre-test and, at the course's conclusion, a post-test and the NIULPE Fourth Class Power Engineer exam, and by comparing the results from the exams. Conclusions were drawn from the objective test results and from the subjective experience of administering and taking the engineering course, and recommendations were made for creating a program to train and certify boiler operators.

Mode of Technology Transfer

The information in this report will be used to support the continuing education and training program the Army has established through USACPW. At the time of this publication, USACPW has contracted to provide operators of Army installation central energy plants NIULPE 4th Class training and certification. It is recommended that the final results of this study be incorporated into Army Regulation (AR) 420-15.

2 Program Description

NIULPE Standard

For over 20 years, industry has recognized the need to standardize the training and certification of central heating personnel with the establishment of the National Institute for the Uniform Licensing of Power Engineers (NIULPE). The DOD working group chose the NIULPE standard since it has precisely identified the knowledge areas and the experience requirements for boiler operators. The NIULPE standard was also chosen since it had an established testing system and national acceptance of competency criteria. Although the NIULPE standard addresses refrigeration and air conditioning equipment as well, the trend in staff reductions necessitates that some boiler operators be tasked to help operate cooling systems during the summer. The additional knowledge requirements can be beneficial in those circumstances.

Skills Assessment

USACERL tasked the Science Applications International Corporation (SAIC) in McLean, VA and Academy of Industrial Training (AIT) in Philadelphia, PA to conduct an independent review of boiler operator skills by producing a list of minimum performance skills and knowledge areas that can be objectively measured. AIT accessed other industry sources outside NIULPE to ascertain the important skills required to operate central heating plant boilers fired by coal, fuel oil, or gas. AIT was to differentiate the skills into different grade levels of operations and maintenance staff. The major system knowledge and skill areas to be examined by AIT were fuel handling and storage, water treatment, combustion controls, plant controls, boilers, heat recovery, air pollution control, waste handling, power generation, plant auxiliaries, and energy distribution systems. The fundamental factors to be used in defining required job skills will be safety, reliability, efficiency, environmental impact, and personnel management.

Resource Identification

USACERL tasked AIT to identify central energy plant operations and maintenance training methods, resources, and reference materials currently available in the government and the private sector. The resources identified should help operators improve or acquire the skills and knowledge identified in the job skill assessment. Training methods to be considered in this task were to include self-training programs (textbook, workbook, video-based, and computer-based), structured on-the-job training, training center-based programs and site-specific training programs.

Additionally, USACERL reviewed other training mechanisms within the DOD. USACERL reviewed active duty and civilian staff publications and training aids. Several initiatives in training and training certification are occurring. The Air Force has two software products to assist in the training, operation, and certification of civilian and military engineering support staff. The first product is a program that assists installation personnel in drafting standard operating procedures (CheckMaster). The software architecture allows installations to share common equipment checklists, and the headquarters to promulgate force-wide procedures. The second product is a program that tests the operator over the information contained in a set of training videotapes (CERTTEST). The software creates random tests based on the criteria input by the test author. Although the active duty Navy has used the Personal Qualification Standard (PQS) system for years, the Navy has recently located the standards on a computer bulletin board to allow ships to download and update their standards quickly.

Training Course

USACERL tasked SAIC to conduct courses at various installations in DOD. At this writing, eight courses have been conducted at Army and Navy installations. The 4½-day courses are intended to refresh the operators on boiler operations and systems. To measure the course's effectiveness, a pre-test and post-test are given. At the end of the course, a NIULPE Fourth Class Power Engineer examination is given to the operators. USACERL specified that different instructors be used at each installation to help filter out the effect of the trainer. Additionally, USACERL collected data on the effectiveness of the course and test by interviewing operators, visiting the heating plants, and observing the conduct of the course.

NAPE Library

NAPE has developed a collection of publications to help its members study for licensing and certification (Appendix B). These publications have been used by heating and cooling operator and maintenance personnel in industry to prepare for license examinations. Additionally, some operators use these publications as part of their continuing education. USACERL has sent these publications to the pilot program bases to assess the usefulness of this resource.

3 Program Results

Course Performance

Courses were given at five Army installations and three Navy bases. The programs conducted at the installation are to measure the validity of the NIULPE standard and the effectiveness of a refresher course. The reception of the program in the field was very positive. The program consisted of conducting a course, testing the operators, observing the plant, and interviewing the personnel.

Pre-Test

All the boiler operators were given a pre-test consisting of 40 to 81 multiple choice questions similar in complexity to the questions on the National Institute for the Uniform Licensing of Power Engineers (NIULPE) Fourth Class Operator exam (Appendix C). This exam helped establish a knowledge base for curriculum assessment. Table 1 summarizes the combined results to date.

Table 1. Pre-test results.

Parameters	Results
Number of operators	125 (1 operator on leave, 6 supervisors unavailable)
Mean Score	64.2
Standard Deviation (middle 68 percent)	16.0
Median Score	64
High Score	98
Low Score	12.5

Post-Test

All the boiler operators were given a post-test near the end of the 4½-day course, which also consisted of 40 to 81 multiple choice questions similar in complexity to the questions on the NIULPE Fourth Class Operator exam (Appendix C). The examination provided feedback on student information retention. The post-test

was similar in content to the pre-test. Table 2 summarizes the results of the post-test.

Table 2. Post-test results.

Parameters	Results
Number of operators	127 (2 operators on leave, 3 supervisors unavailable)
Mean Score	83.3
Standard Deviation (the middle 68%)	12.7
Median Score	86
High Score	100
Low Score	40

NIULPE 4th Class Boiler Operator Examination

At the end of the course an independent examiner administered the NIULPE Fourth Class Operator Examination. The exam consisted of 50 multiple choice questions worth two points each. The NIULPE examination frequently appeared more difficult for the operators than the pre-tests or post-tests. Table 3 summarizes the results of the NIULPE examination.

Table 3. NIULPE examination results.

Parameters	Result
Number of operators	123 (2 operators on leave, 1 operator unavailable, 2 operators took 3rd class exam, 3 operators took 1st class exam, 1 operator took chief's exam)
Mean Score	73.4
Standard Deviation (middle 68%)	10.7
Median Score	74
High Score	94
Low Score	38
Passing Rate	82% (105 of 123, including (2) 3rd class passes and (1) 1st class pass)

Another contractor-operated facility tested their operators without the benefit of a training course. Only 4 of 13 operators (31 percent) were able to pass the NIULPE Fourth Class certification. Those scores are not included in the program statistical summary since the examinees were not able to attend a training course.

The test examiners reported the following common weak areas of knowledge: electricity, required wire sizes, refrigeration cycle, pump curves, boiler water level control, boiler types, boiler blowdown requirements, water level checks, water treatment, compressors, trigonometry, math

Operator Motivation and Knowledge

Operator Motivation

Most of the boiler operators displayed enthusiasm and interest in the course. A few older operators indicated that they thought the course applied more to the younger operators. Some of these older operators maintained that they would retire if certification were too difficult a requirement. However, the majority of operators were very interested and were observed helping each other study and challenging each other with questions from the course material. Questions and comments from the operators at the beginning of class each day indicated that several of the operators studied the course material at night. There was complete attendance even though many of the operators worked an 8-hour shift at night after class. Some of the operators that missed the class due to working day shift asked for extra instruction and course materials so that they could participate in the examination.

Operator Knowledge

The operator baseline knowledge level ranged from poor to very good. At installations where several of the operators had previously held local operator or other state board licenses, the level of knowledge seemed higher. Additionally, some of the operators with prior naval service as boiler operators scored better than average. These individuals appeared to help maintain a higher level of corporate knowledge at their particular installations. The improvement in scores from the pre-test to the post-test indicated that the course had raised the operators' knowledge level. However, the decline in license exam scores as compared to the post-test suggests that the pre-test and post-test examinations were not as difficult for the operators as the actual fourth class examination (Figure 1). Even though not all of the operators passed the NIULPE examination, there appears to be sufficient determination and interest among some of those who failed to indicate that they will continue to study and retake the examination.

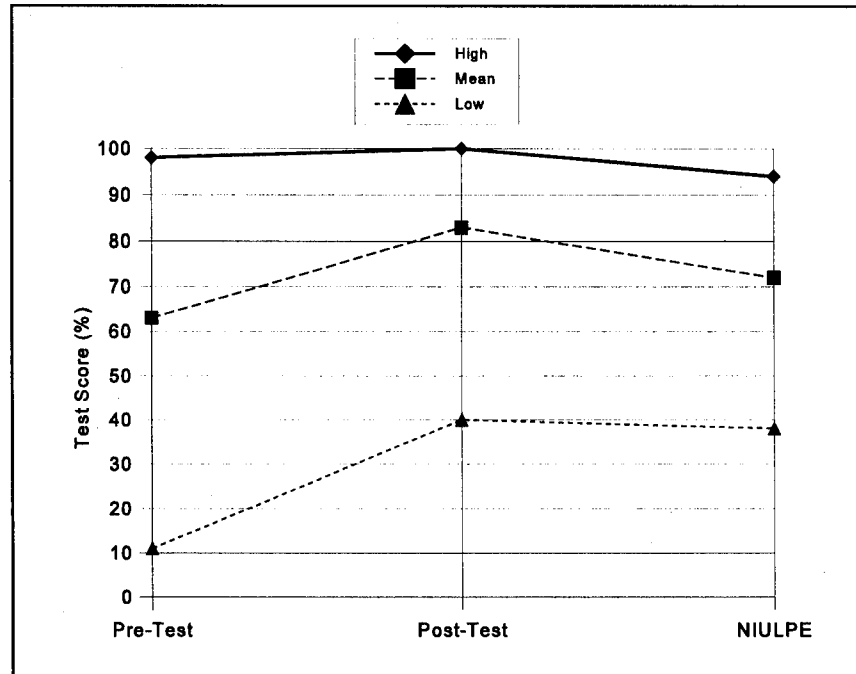


Figure I. Boiler operator score data.

Plant Management and Operations

Engineering Management and Leadership

At all installations the supervisory personnel were enthusiastic and supportive of the boiler operator training. The plant management did a superb job in arranging classroom facilities and allowing tours of the plants. The plant management was very interested in the training and willing to adjust the work schedule to support the training.

Plant Operations

The general condition of the central heating systems ranged from fair to excellent. Although the scope of the visit was not to inspect the plants, the tours of the plant revealed some discrepancies that were acted on by the personnel present. The tours were conducted to provide a laboratory lecture and allow the students to explain the operation of their plant as an educational exercise.

Assessment of Course Provider

Instructor Knowledge and Motivation

Most of the instructors were interested and knowledgeable individuals. Those who had extensive experience as boiler operators or boiler supervisors quickly established credibility with the students. Additionally, some of the instructors availed themselves to give individual instruction to those operators who needed extra tutoring.

Course Content

Each instructor was allowed to design a syllabus and select materials for the course. In general, most instructors distributed a single notebook or text to each operator. At one installation, the instructor used three separate sets of notes for his lectures. The syllabus formats generally followed the progression of the text or notebook with the instructor using overhead projections or videos for supplemental information.

The curriculum strategy of using one main text or notebook was very useful to the students. The use of a single, well-indexed book allowed the operators to study on their own. Additionally, a text or notebook can provide a convenient study resource as the operators pursue higher levels of qualification.

The curriculum structure needed more attention as presented at some installations. Some of the courses appeared to review at the expense of covering other pertinent material. Although a greater amount of review seems to be warranted for older students, it is important to cover all of the required knowledge areas. Poor organization in the review effort resulted in the topics covered near the end of the week sometimes being denied needed explanation. It would have been profitable to spend more time discussing and reviewing electricity and refrigeration cycles earlier in the week as evidenced by poor performance in the NIULPE examination in those topics. Additionally, any future course should acknowledge the DOD guidance and regulation on safe and efficient boiler operation.

Assessment of Examiners

The examiners did a good job administering the NIULPE examination and explaining the significance of the NIULPE license. Many of the examiners counseled each operator on completing the grading of the examination. The effort

of some examiners to discuss the problems and successes each operator experienced with the test had a positive effect on the morale of the class.

Certification Implementation

USACERL initiated discussions with the Office of Personnel and Management (OPM) and some DOD personnel offices to investigate the mechanisms for implementing a boiler operator certification. The primary mechanism that has been used to enforce and implement certifications in other federal positions has been the terms of employment and position description (Appendix D). OPM has advised the DOD not to make licensing or certification a wage grade issue. OPM recommends that any certification be a condition of employment to meet minimum safety, health, or environmental requirements. Experience has shown that certification has already been successfully enforced with these mechanisms for welders, water treatment plant operators, and nondestructive testing technicians. OPM discussed a case with USACERL in which the failure of a welder to maintain a certification resulted in reassignment of that person to a position not requiring such certification.

4 Further Work

Standard Boiler Operator Training Course

The U.S. Army Center for Public Works (CECPW) has established an indefinite delivery order to procure 5-day training courses for Army installations to provide NIULPE Fourth Class training and certification. The specifications for the courses were based on the results of the successful pilot program courses. Appendix E is a sample course schedule and budget that was used in the contract documentation for some of the successful courses and the CECPW delivery order. The CECPW delivery order will give the field managers a mechanism to procure more courses for their installations. It would be useful to closely monitor the reception of the course in the field and to continue to measure the results from the 1-week courses to identify training weaknesses that need remediation by other means. Although the pilot program has shown that a 1-week course alone can not rectify all training deficiencies, the course can be a valuable part of an installation's continuing education and training program.

Specifications for any training course should be detailed enough to ensure that training is carried out efficiently. The CECPW course and any other future course should show the characteristics of the successful courses in the pilot program.

Course Learning Objectives

The course should cover the topics listed in the NIULPE Fourth Class Power Engineer Curriculum (Appendix F). The only learning objective not mentioned by name in the NIULPE standard is the training on the legal requirements pertaining to boiler operations on DOD installations. It is important that the course address these requirements in the syllabus.

Course Structure

The course should cover the NIULPE topics in an orderly fashion balancing review with new material each day. Based on operator feedback, it is recommended that some of the more difficult topics such as electricity and refrigeration equipment be covered early in the course to afford the instructor opportunity to conduct extra review or to allow operators time to study on their own. The model course

schedule in Appendix E is constructed to provide this balance and to afford the operators opportunity to attack the more difficult topics earlier in the course. The amount of time devoted to the various topics was based on USACERL observation of operator performance on the exam and operator feedback from interviews.

Course Materials

Although there are a variety of industrial courses and study guides, the instructor should modify his presentation to use the NAPE materials. The instructor should reference his presentation to specific sections in NAPE-recommended reading materials. This will reinforce the self-study efforts of the operators before and after the course. Additionally, for each learning objective the instructor covers, the students should be informed of the precise NIULPE topic under review to assist the self-study process.

Instructor Credentials

The instructor should have extensive experience as a heating or power production operator or supervisor to quickly gain the respect of the seasoned operators. The instructor must be a certified NIULPE Technical Instructor and a licensed NIULPE Chief Engineer to ensure that quality courses are conducted. Additionally, the instructor must be willing to give references from previous clients to help establish the instructors effectiveness before using his services.

At the completion of the course, the examination must be administered by a separate interest from the instructing agency or company. Although some industry instructors are also licensed as examiners, this separation of tasks is healthy to reduce the tendency of an instructor to teach the examination instead of the curriculum.

DOD Boiler Operators Study Book

USACERL has reviewed some of the publications in the NAPE library (Appendix B) and found them to be useful. With the permission of NAPE, USACERL duplicated and bound six of the NAPE publications to be used as a pre-course study book. USACERL constructed a study guide (Appendix G) to direct the operator to specific locations in the study book that address NIULPE curriculum topics for fourth class operators. Additionally, within the NAPE library, there are several home study courses. It may be fruitful to develop an update to one of these courses with the permission and cooperation of NAPE. This book could be a single source to help the operator prepare for the certification exam. Another

possibility is to adapt portions of existing Air Force, Navy, Army, and EPA training books into a single home study book.

Computer-Based Tutor

Many of the bases have computers located in the heating plants for other administrative functions. USACERL has reviewed the Air Force CERTEST program and found it to be a good testing tool. However, this product may be even more beneficial as a tutoring tool. USACERL has constructed a NIULPE tutoring module with the current CERTEST program to obtain some operator feedback on the usefulness of such a product (Appendix H). The field demonstrations were positive and USACERL has drafted a proposal (Appendix I) to build on the existing CERTEST platform to create a central heating plant tutor (CHPTUTOR) for use throughout DOD.

Regulation Issues

Even though certification is presently required, the implementation has not fully met the intent of the regulations. It is essential that the mechanisms be in place to enable currently employed operators who are motivated to become certified. Additionally, the job description and job training resources must be consistent with the certification required. Workforce morale is undermined when the documented job requirements and certifications are not supported by job training. The four items of the actual work performed, the documented job description, the job training resource, and the job skill certification must complement each other to maintain a quality workforce.

Design a Continuing Education Program

As indicated by the poor performance on the NIULPE tests, DOD installations will need to implement and maintain continuing training and education resources to augment a training course. With fewer operators responsible for more complex equipment, it is critical that the operator be supported with quality training. A variety of resources should be identified or designed such as home study courses, computer based tutorial, video training series, or refresher courses. An ongoing technical training and professional development program is a vital part of operating DOD plants efficiently, cleanly, and safely.

NAPE Library

Operators should have materials available to help further their technical knowledge. It is recommended that installations establish training libraries in the heating and cooling shops where no such a library currently exists. An excellent start would be the NAPE library collection (Appendix B) and a subscription to the *National Engineer*, the professional magazine of NAPE.

Boiler Operator Study Book

As mentioned above, a single study book to assist the motivated operator to prepare for certifications would be useful. Several of the NAPE publications would be good candidates for such a book. Development of the study guide may be a good opportunity to partner with industry and professional educational organizations such as NAPE to produce a mutually beneficial training tool.

Computer-Based Tutor (CHPTUTOR)

The presence of computers in central heating plants for administrative functions may provide another avenue to deliver training. The U.S. Air Force CERTEST program has been eagerly accepted as a training product. The primary criticism from the field is the lack of feedback on incorrect answers and the lack of referencing to the source of the correct answer. Although the purpose of CERTEST is only to test and not to train, these modifications would be achievable with the present product. USACERL has drafted a proposal (Appendix I) to modify the current CERTEST into a tutoring tool. The computer tutor could guide the student through each of the NIULPE topics at the students pace. Incorrect answers from the student would elicit a response and direct the student to the precise location in a study book, technical manual, training videotape or operating code book to find the answer. On completion of the training module, the student would take a test using the original CERTEST software architecture to protect the integrity of the CERTEST test bank. Additionally, the student could be given the opportunity to take a simulated NIULPE examination to help prepare for the actual NIULPE examination. Such a system could document operator progress as well as help direct the self-study efforts of operators.

Formal Continuing Education Classes

Licensed operators should have opportunity to participate in continuing education to maintain their proficiency. Installations should consider conducting 1 day in-house training classes quarterly or semi-annually to update operators and reinforce good operational practices. Additionally, installations should consider

some sort of tri-annual licensing or refresher class to maintain the corporate knowledge base. This is important considering that higher classes of licenses may be required for operators of large or more complex plants (Appendix J). Many of the operators who attended the pilot course commented that this was the first course that they had ever been given in their entire federal service careers. An unintentional benefit of the course was the cross training among the operators at an installation. During classroom discussions, many of the operators shared technical information about the equipment with the class that was apparently new to the less experienced operators.

U.S. Air Force Boiler Tune-Up Workshop

USACERL developed a series of workshops to train USAF personnel in proper operation and maintenance procedures. The series covers much more information than a fourth class operator would be expected to learn. However, the series is on videotape and available for use inside DOD (Appendix K). The tapes would assist operators pursuing higher levels of qualification.

NUS Training Tapes

The Department of Defense purchased a series of plant maintenance and operation training videos from the NUS Training Corporation. These tapes cover a wide variety of topics in basic and advanced skill levels. Additionally, NUS has produced work books to accompany the tapes. These materials may be a resource from which an installation could conduct an in-house training course.

5 Conclusions and Recommendations

This study has identified the major system knowledge and skill areas required to safely and efficiently operate DOD central energy plants as:

- fuel handling and storage
- water treatment
- operation of combustion controls
- operation of plant controls
- boiler operation
- heat recovery
- air pollution control
- waste handling
- power generation
- use and maintenance of plant auxiliaries
- energy distribution systems.

In general, coursework should be formulated to address the topics listed in the NIULPE Fourth Class Power Engineer Curriculum (Appendix F), which gives a good overview of these needed areas. One area not mentioned in the NIULPE standard is training in the legal requirements pertaining to boiler operation on DOD installations. Operator training courses should be designed to address this as well. Special attention should also be given to the following subjects identified in the pilot program as relatively weak:

- electricity
- required wire sizes
- refrigeration cycle
- pump curves
- boiler water level control
- boiler types
- boiler blowdown requirements
- water level checks
- water treatment
- compressors
- mathematics.

USACERL recommends that the NIULPE examination standard tentatively be used as a qualification standard for operators of DOD central heating plants. However, full adoption of the NIULPE standard should be delayed until it is clear that the USEPA standard will not disqualify the use of the NIULPE certification to meet the intent of the CAAA 1990. Since the purpose of the NIULPE is to establish a uniform procedure to measure the knowledge of operators across a variety of facilities, it seems reasonable that DOD installation boiler operators should be able to meet the NIULPE standard. Additionally, a NIULPE certification or a similar USEPA standard may start to be a federal and state requirement due to the CAAA 1990 mandate to improve air quality. Furthermore, the DOD should continue work with the USEPA to ensure DOD training and certification mechanisms are in agreement with the forthcoming USEPA standard.

It is recommended that all operators be required to have a fourth class license (by examination) as a minimum. This training is currently available through the U.S. Army Center for Public Works (USACPW), which, based on the recommendations of the DOD study group, has put a contract in place to provide NIULPE 4th class training and certification. Higher classes of licenses may be required for operators of large or more complex plants (Appendix J). Additionally, all operators should be required to fulfill some sort of recertification every 3 to 5 years to ensure proficiency is maintained. The recertification could be met with a variety of mechanisms, e.g., retaking a certification exam, successful completion of a course, or successful completion of a computer-based test. During the implementation period current operators should be given a generous amount of time (12 to 24 months) and multiple opportunities (four to six attempts) to pass the exam. However, discussions with operators and supervisors in industry suggest that there should not be grandfathering of current employees as this will undermine the validity of the certification. Although the scope of this pilot program was for operators only, it is recommended the NIULPE certification also be the standard for supervisory and plant engineering personnel as well.

Acronyms and Abbreviations

AFR	Air Force Regulations
AR	Army Regulation
ASME	American Society of Mechanical Engineers
CAAA 1990	Clean Air Act Amendments of 1990 of the 101st Congress
CECPW	U.S. Army Center for Public Works, Fort Belvoir, VA
CERTEST	U.S. Air Force computer-based skills test
CheckMaster	U.S. Air Force infrastructure equipment procedure checklist computer program
DOD	Department of Defense
NAPE	National Association of Power Engineers
NFESC	Naval Facilities Engineering Service Center Activity, Port Hueneme, CA
NIULPE	National Institute for the Uniform Licensing of Power Engineers
OPM	Office of Personnel and Management
USACERL	U.S. Army Construction Engineering Research Laboratories
USEPA	U.S. Environmental Protection Agency

Appendix A: Clean Air Act Amendments

Section 305

P.L. 101-549
Sec. 305

LAWS OF 101st CONG.—2nd SESS.

Nov. 15

Regulations

days of the submission, and if a plan is disapproved, the Administrator shall state the reasons for disapproval in writing. Any State may modify and resubmit a plan which has been disapproved by the Administrator.

"(3) FEDERAL PLAN.—The Administrator shall develop, implement and enforce a plan for existing solid waste incineration units within any category located in any State which has not submitted an approvable plan under this subsection with respect to units in such category within 2 years after the date on which the Administrator promulgated the relevant guidelines. Such plan shall assure that each unit subject to the plan is in compliance with all provisions of the guidelines not later than 5 years after the date the relevant guidelines are promulgated.

"(c) MONITORING.—The Administrator shall, as part of each performance standard promulgated pursuant to subsection (a) and section 111, promulgate regulations requiring the owner or operator of each solid waste incineration unit—

"(1) to monitor emissions from the unit at the point at which such emissions are emitted into the ambient air (or within the stack, combustion chamber or pollution control equipment, as appropriate) and at such other points as necessary to protect public health and the environment;

"(2) to monitor such other parameters relating to the operation of the unit and its pollution control technology as the Administrator determines are appropriate; and

"(3) to report the results of such monitoring.

Such regulations shall contain provisions regarding the frequency of monitoring, test methods and procedures validated on solid waste incineration units, and the form and frequency of reports containing the results of monitoring and shall require that any monitoring reports or test results indicating an exceedance of any standard under this section shall be reported separately and in a manner that facilitates review for purposes of enforcement actions. Such regulations shall require that copies of the results of such monitoring be maintained on file at the facility concerned and that copies shall be made available for inspection and copying by interested members of the public during business hours.

"(d) OPERATOR TRAINING.—Not later than 24 months after the enactment of the Clean Air Act Amendments of 1990, the Administrator shall develop and promote a model State program for the training and certification of solid waste incineration unit operators and high-capacity fossil fuel fired plant operators. The Administrator may authorize any State to implement a model program for the training of solid waste incineration unit operators and high-capacity fossil fuel fired plant operators, if the State has adopted a program which is at least as effective as the model program developed by the Administrator. Beginning on the date 36 months after the date on which performance standards and guidelines are promulgated under subsection (a) and section 111 for any category of solid waste incineration units it shall be unlawful to operate any unit in the category unless each person with control over processes affecting emissions from such unit has satisfactorily completed a training program meeting the requirements established by the Administrator under this subsection.

"(e) PERMITS.—Beginning (1) 36 months after the promulgation of a performance standard under subsection (a) and section 111

Appendix B: NAPE Library List

The publications included in the following list are taken from the NAPE Engineering Library and the are available by mail order. To order, indicate publication number and mail order to:

National Engineer
5-7 Springfield Street
Chicopee, MA 01013
Ph: 413-592-6273
FAX: 413-592-1998

Number	Publication Name	Cost
1.	<i>Boiler Plant Operation</i> , by Woodruff	\$3.50
2.	<i>Electric Motors and Generators</i>	\$3.50
3.	<i>Refrigeration</i>	\$3.50
4.	<i>Combustion</i>	\$3.50
5.	<i>Fundamentals of Air Conditioning</i>	\$3.25
6.	<i>Fuel Oil and Its Combustion</i> , by Roulton	\$4.50
7.	<i>Automatic Combustion Control</i> , by Lammers	\$3.50
8.	<i>Fundamental of Heat</i> , by Hiss	\$3.00
9.	<i>Modern Boiler Plant Management</i>	\$3.25
10.	<i>How To Establish Power Plant Operating Records and Costs</i> , by Dick	\$3.00
11.	<i>How To Run a Boiler Test</i> , by Moe	\$3.00
12.	<i>Flow of Steam and Water in Piping</i>	\$3.00
13.	<i>Engineering Investigation and Reports</i> , by Roulton	\$3.00
14.	<i>Steam Turbine Operation and Maintenance</i> , by Allen	\$3.00
15.	<i>Engineer's IQ</i>	\$3.25
16.	<i>Typical Questions for Engineer's License Examinations</i>	\$2.85
17.	<i>Study Questions on Boilers and Combustion</i>	\$3.00

Number	Publication Name	Cost
18.	<i>Refrigeration Engineer's Guide to Practical Plant Operations</i> , by Baker	\$3.50
19.	<i>Steam Plant Operation</i>	\$6.00
20.	<i>Coal and Its Combustion</i> , by Harrington	\$5.00
21.	<i>Fundamentals of Atomic Energy</i>	\$3.00
22.	<i>How To Prepare for License Examinations</i> , by Hill	\$3.75
23.	<i>Basic Electricity</i>	\$9.25
24.	(Reserved, Not Available)	
25.	<i>Stationary Engineering</i>	\$10.00
25A.	<i>Stationary Engineering Answer Book</i>	\$5.00
26.	<i>Low Pressure Boilers</i> , by Steingrass	\$19.50
26A.	<i>Low Pressure Boiler Workbook</i> , by Steingrass	\$11.50
27.	<i>High Pressure Boilers</i> , by Steingrass	\$27.50
28.	<i>National Institute for the Uniform Licensing of Power Engineers, Inc.</i>	\$2.25
29.	<i>Practical Electrical Wiring</i> , by Richter	\$37.00
30.	<i>Steam Plant Operation</i> , by Woodruff	\$62.00
31.	<i>Modern Refrigeration and Air Conditioning</i> , by Althouse	\$34.00
32.	<i>Boiler Operators Workbook</i> , by Wilson	\$29.50
32A.	<i>Boiler Operators Workbook Instructors Guide</i>	\$8.50
33.	(Reserved, Not Available)	
34.	<i>Diesel Engines and High Compression Gas Engines</i> , by Kates	\$23.50

Appendix C: Boiler Operator Training Tests

Fourth Class Operator Pretest

1. Proper combustion of oil produces a flame in the color of
 - a. yellow
 - b. green
 - c. red
 - d. blue

2. The primary function of bottom blowdown is to
 - a. remove sludge
 - b. remove excess water
 - c. remove excess chemicals
 - d. relieve excess pressure

3. The first duty of an engineer coming on duty is
 - a. check boiler temperature
 - b. check boiler water level
 - c. check boiler pressure
 - d. check for boiler leaks

4. Heat transfer methods are
 - a. radiation, reflection, infiltration
 - b. convection, radiation, lumens
 - c. as defined in ASHRAE 63-1989
 - d. radiation, convection, conduction
 - e. combustion, convection, radiation

5. Boiler feed water control is
 - a. to control pressure
 - b. to control temperature
 - c. to control safety valves
 - d. to control water level

6. I can continue to run my boiler
 - a. with a tube failure
 - b. with a steam drum leak
 - c. with a safety valve blowing
 - d. with a gauge glass broken
 - e. with refractory failure
7. The most important safety feature of my boiler is
 - a. the burner switch
 - b. the safety valve
 - c. the fuel pressure regulator
 - d. the flame control
8. The primary cause of a furnace explosion is
 - a. low water
 - b. high chlorine
 - c. combustible gas build-up
 - d. leaking steam drum
9. Eccentricity is a measure of
 - a. shaft vibration
 - b. shaft alignment
 - c. shaft straightness
 - d. all of the above
10. An economizer functions as
 - a. an air preheater
 - b. a superheater
 - c. a regulator
 - d. a feedwater preheater
11. A soot (tube) blower should be operated
 - a. when windy conditions exist
 - b. only when firing with coal
 - c. daily
 - d. once per shift
 - e. when required, see manufacturer

12. The result of turbine water induction can be
 - a. turbine casing cracks
 - b. excessive vibration
 - c. rubbing of moving and stationary parts
 - d. all of the above
13. A power turbine is normally driven by
 - a. water
 - b. steam
 - c. feed water
 - d. the deaerator
 - e. the exhaust
14. The most functional way of removing corrosive oxygen (O₂) is
 - a. chemical treatment
 - b. deaeration
 - c. spraying
 - d. superheating
 - e. boiling
15. A steam turbine normally exhausts into a
 - a. deaerator
 - b. feed pump
 - c. condensate pump
 - d. condenser
16. Condensate removed from a steam system is
 - a. worthless
 - b. in need of severe chemical treatment
 - c. recoverable
 - d. dirty
 - e. not economically salvageable
17. Relief valves are used primarily for relieving pressure in
 - a. liquid systems
 - b. gas or vapor systems
 - c. solids systems
 - d. steam systems

18. Boiler feed water pumps operate
 - a. at higher than boiler pressure
 - b. at lower than boiler pressure
 - c. at higher than turbine pressure
 - d. at lower than turbine pressure
 - e. at any reasonable pressure

19. Safety valves are used primarily for relieving pressure in
 - a. fluid systems
 - b. gas or vapor systems
 - c. solids systems
 - d. water systems

20. Pumps are specified by curves, which
 - a. indicate dimensions
 - b. indicate motor horsepower
 - c. indicate size of rotor
 - d. indicate capacity and head
 - e. indicate uses

21. Combustion is actually a _____ process.
 - a. electrical
 - b. mechanical
 - c. chemical
 - e. pneumatic

22. Ohms law states that current (I) equals
 - a. voltage (E) divided by resistance (R)
 - b. resistance (R) divided by voltage (E)
 - c. amps times volts
 - d. volts times watts

23. In air conditioning terms, one ton equals
 - a. 1,000 BTU's per hour
 - b. 12,000 BTU's per hour
 - c. 1,000 KWH
 - d. 12,000 KWH
 - e. 500 square feet

24. A British Thermal Unit (BTU) is the heat required to raise one (1) pound of water, at sea level, one (1) degree fahrenheit (F). Therefore, to raise twenty (20) pounds of water from a street water main temperature of sixty-two (62°F) degrees to boiling at 212°F, requires:
- 3000 BTU's
 - 30,000 BTU's
 - one half hour
 - 15 minutes
 - 5 minutes
25. In the refrigeration cycle, the following actually does the cooling
- the compressor
 - the thermostat
 - the accumulator
 - the condenser
 - the evaporator
26. A hermetic compressor in a chiller is cooled by
- compression
 - the refrigerant
 - evaporation
 - water
 - coil
27. The heat used to change a liquid to a gas or vapor is called
- the latent heat of adsorption
 - the latent heat of absorption
 - the latent heat of vaporization
 - the latent heat of fusion
 - the latent heat of liquids
28. Electricity consumption is measured and sold by
- the demand
 - kilovolt ampere (KVA)
 - kilowatt hour (KWH)
 - kilowatt (KW)
 - kilovolt (KV)

29. North American utilities sell electricity in A.C. at 60 Hertz, meaning
- direct current with 60 cycles per minute
 - direct current with 60 cycles per second
 - alternating current with 60 cycles per minute
 - alternating current with 60 cycles per second
 - a higher electric bill than normal
30. Transformers
- provide metering methods
 - change voltage levels
 - add capacity
 - subtract capacity
 - redirect electrical services
31. Gate valves are used primarily as
- control valves
 - throttle valves
 - isolation valves
 - safety valves
32. In the refrigeration cycle, the _____ is immediately downstream of the expansion device.
- motor
 - evaporator
 - condenser
 - compressor
33. Check valves are used to
- throttle flow
 - relieve excessive pressure
 - allow flow in one direction only
 - relieve excessive level
34. Latent heat is heat that
- can be measured with a thermometer
 - cannot be measured with a thermometer
 - is created by pipe friction only
 - is unrelated to heating and refrigeration plant operation

35. In air conditioning systems, the primary principle is
- rejection of heat
 - addition of cooling
 - addition of energy
 - thermostat setting
36. A minimum of _____ safety valves are required on all boilers of over 500 sq ft
- 1
 - 2
 - 3
 - 4
37. Sensible heat is heat that
- can be measured with a thermometer
 - cannot be measured with a thermometer
 - is crested by pipe friction only
 - is unrelated to heating and refrigeration plant operation
38. Fuses in electrical systems
- prevent excessive current flows
 - open a circuit in the event of overheating
 - prevent damage to circuit components
 - all the above
39. Which of the following combustion products is an indication of incomplete combustion?
- excess air
 - carbon dioxide
 - sulfur dioxide
 - carbon monoxide
40. On a fire tube boiler, the low water shut off valve _____ in the event of low water level.
- opens the boiler drains
 - opens the boiler make-up valve
 - increases fuel flow
 - shuts off fuel flow

41. A pump pumps 300 GPM. If it runs for an hour it will pump
- 1,800 gallons
 - 18,000 gallons
 - 180,000 gallons
 - 1,800,000 gallons
42. In a fire tube boiler, the flue gases flow through the
- furnace area
 - the boiler tubes
 - the windbox
 - the water tubes
43. Heating number 6 fuel oil
- makes it thicker
 - increases its viscosity
 - decreases its viscosity
 - increases its pour point
44. A gauge pressure reading of 14.7 psig is equal to an absolute pressure reading of what?
- 24.7 psia
 - 0 psia
 - 14.7 psia
 - 29.4 psia
45. If a boiler has 10,500,000 BTUs of heat input every hour and the steam leaving the boiler every hour contains 9,500,000 BTUS, the boiler has an efficiency of
- 100%
 - 95.5%
 - 90.5%
 - 9.5%
46. What is the purpose of an economizer section of a boiler?
- To recover flue gas BTU's leaving the boiler
 - To preheat boiler gas before pollution control
 - An economizer preheats primary or secondary air
 - An economizer is used to increase secondary superheat temperature

47. In some boilers coal is pulverized to
- increase the percentage of fuel surface area exposed to heat and oxygen
 - make it easier to transport to the furnace for burning
 - decrease the cost of furnace combustion equipment
 - decrease the amount of pollutants produced
48. Solenoid valves use _____ to operate.
- manual levers
 - pneumatic actuators
 - electro magnetism
 - electric motors
49. In the operation of a safety valve, the term "blow down" or "blowback" refers to
- the pressure at which the valve opens
 - the difference between valve opening and closing pressures
 - the pressure at which the valve closes
 - the volume of gas released by the valve when it is open
50. _____ can be found by multiplying volts and amps.
- Ohms
 - Hertz
 - Watts
 - Resistance

Fourth Class Operator Post Test

1. Proper combustion of pulverized coal produces a flame in the color of
- yellow
 - green
 - red
 - blue
 - does not matter

2. The primary function of boiler blowdown is to prevent
 - a. low water levels
 - b. excess water levels
 - c. accumulation of chemicals
 - d. excess pressure
 - e. accumulation of sludge
3. The first duty of an engineer coming on duty is
 - a. check boiler temperature
 - b. check boiler water level
 - c. check boiler pressure
 - d. check for boiler leaks
 - e. check for boiler safety settings
4. Heat transfer methods are
 - a. radiation, reflection, infiltration
 - b. convection, radiation, lumens
 - c. as defined in ASHRAE 63-1989
 - d. radiation, convection, conduction
 - e. combustion, convection, radiation
5. Boiler feed water control is used
 - a. to control pressure
 - b. to control temperature
 - c. to control safety valves
 - d. to control water level
 - e. to control chemistry
6. I can continue to run my boiler
 - a. with a tube failure
 - b. with a steam drum leak
 - c. with a safety valve blowing
 - d. with a gauge glass broken
 - e. with refractory failure

7. The most important safety feature of my boiler is
 - a. the burner switch
 - b. the low water cut-off
 - c. the safety valve
 - d. the fuel pressure regulator
 - e. the flame control

8. The primary cause of a furnace explosion is
 - a. low water
 - b. low pH
 - c. high chlorine
 - d. combustible gas build-up
 - e. leaking steam drum

9. One British Thermal Unit (BTU) is equal to the amount of energy needed to _____ at atmosphere pressure.
 - a. increase the temperature of one pound of water one degree Fahrenheit
 - b. increase the temperature of one pound of water one degree centigrade
 - c. increase the temperature of one gallon of water one degree centigrade
 - d. increase the pressure of one gallon of water one PSI

10. An economizer functions as
 - a. an air preheater
 - b. a superheater
 - c. a regulator
 - d. a feedwater preheater
 - e. a condenser

11. A soot (tube) blower should be operated
 - a. when windy conditions exist
 - b. only when firing with coal
 - c. daily
 - d. once per shift
 - e. when required

12. The result of turbine water induction can be _____
- a. turbine casing cracks
 - b. excessive vibration
 - c. rubbing of moving and stationary parts
 - d. all of the above
13. The critical speed of a turbine is the speed at which the turbine
- a. rotor vibrates excessively
 - b. is ready for loading
 - c. reaches the overspeed limit
 - d. none of the above
14. The most functional way of removing corrosive oxygen (O_2) is
- a. chemical treatment
 - b. deaeration
 - c. spraying
 - d. superheating
 - e. boiling
15. The viscosity of a fuel oil refers to its ability to _____
- a. burn
 - b. flow
 - c. lubricate
 - d. seal
16. Condensate removed from a steam system is
- a. worthless
 - b. in need of severe chemical treatment
 - c. recoverable
 - d. dirty
 - e. not economically salvageable
17. Safety valves are used primarily for relieving pressure in
- a. fluid systems
 - b. gas or vapor systems
 - c. solids systems
 - d. steam systems

18. Boiler feed water pumps operate
 - a. at higher than boiler pressure
 - b. at lower than boiler pressure
 - c. at higher than turbine pressure
 - d. at lower than turbine pressure
 - e. at any reasonable pressure
19. Relief valves are used primarily for relieving pressure in
 - a. fluid systems
 - b. gas or vapor systems
 - c. solids systems
 - d. steam systems
20. Pumps are specified by curves, which
 - a. indicate dimensions
 - b. indicate motor horsepower
 - c. indicate size of rotor
 - d. indicate capacity and head
 - e. indicate uses
21. Combustion is actually a process.
 - a. electrical
 - b. mechanical
 - d. chemical
 - e. pneumatic
22. Ohms law states that Voltage (E) equals _____
 - a. current (I) times resistance (R)
 - b. current (I) divided by resistance (R)
 - c. amps times volts
 - d. ohms times watts
23. In air conditioning terms, one ton equals
 - a. 1,000 BTU's per hour
 - b. 12,000 BTU's per hour
 - c. 1,000 KWH
 - d. 12,000 KWH
 - e. 500 square feet

24. _____ is a term used to describe the total energy contained in steam.
- a. temperature
 - b. pressure
 - c. entropy
 - d. enthalpy
25. In room air conditioners, air is cooled as it is blown across the
- a. condenser
 - b. compressor
 - c. expansion valve
 - d. evaporator
26. A hermetic compressor in a chiller is cooled by
- a. compression
 - b. the refrigerant
 - c. evaporation
 - d. water
 - e. coil
27. The heat used to change a liquid to a gas or vapor is called
- a. the latent heat of adsorption
 - b. the latent heat of absorption
 - c. the latent heat of vaporization
 - d. the latent heat of fusion
 - e. the latent heat of liquids
28. Electricity consumption is measured and sold by
- a. the demand
 - b. kilovolt ampere (KVA)
 - c. kilowatt hour (KWH)
 - e. kilowatt (KW)
 - f. kilovolt (KV)
29. Pneumatic control systems use _____ to convey control signals.
- a. electricity
 - b. oil
 - c. air
 - d. water

30. Electrical transformers
- a. provide metering methods
 - b. change voltage levels
 - c. add capacity
 - d. subtract capacity
 - e. redirect electrical services
31. Globe valves are used primarily as _____
- a. throttle valves
 - b. isolation valves
 - c. safety valves
 - d. relief valves
32. Both valves on a water glass must be open to provide _____
- a. circulation of water
 - b. a true level indication
 - c. a good vacuum
 - d. proper heating of the glass
33. Check valves are used to
- a. throttle flow
 - b. relieve excessive pressure
 - c. allow flow in one direction only
 - d. relieve excessive level
34. Sensible heat is heat that _____
- a. can be measured with a thermometer
 - b. cannot be measured with a thermometer
 - c. is created by pipe friction only
 - d. is unrelated to heating and refrigeration plant operation
35. Freon is very suitable for use in refrigeration systems due to its
- a. density
 - b. high temperature boiling point
 - c. low temperature boiling point
 - d. extremely low cost

36. A minimum of _____ safety valves are required on all boiler of over 500 sq ft
- 1
 - 2
 - 3
 - 4
 - 5
37. Latent heat is heat that _____
- can be measured with a thermometer
 - cannot be measured with a thermometer
 - is created by pipe friction only
 - is unrelated to heating and refrigeration plant operation
38. Fuses in electrical systems _____
- prevent excessive current flows
 - open a circuit in the event of overheating
 - prevent damage to circuit components
 - all the above
39. Which of the following combustion products is an indication of incomplete combustion?
- excess air
 - carbon dioxide
 - sulfur dioxide
 - carbon monoxide
40. On a fire tube boiler, the low water shut off valve _____ in the event of low water level.
- opens the boiler drains
 - opens the boiler make-up valve
 - increases fuel flow
 - shuts off fuel flow
41. A pump pumps 500 GPM. If it runs for two hours it will pump
- 3000 gallons
 - 6,000 gallons
 - 60,000 gallons
 - 3,000,000 gallons

42. In a fire tube boiler, the flue gases flow through the _____
- furnace area
 - the boiler tubes
 - the windbox
 - the water tubes
43. Heating number 6 fuel oil
- makes it thicker
 - increases its viscosity
 - decreases its viscosity
 - increases its pour point
44. A gauge pressure reading of 14.7 psi is equal to an absolute pressure reading of what?
- 24.7 psia
 - 0 psia
 - 14.7 psia
 - 29.4 psia
45. If a boiler has 10,500,000 BTUs of heat input every hour and the steam leaving the boiler every hour contains 9,500,000 BTUS, the boiler has an efficiency of _____
- 100%
 - 95.5%
 - 90.5%
 - 9.5%
46. What is the purpose of an economizer section of a boiler?
- To recover flue gas BTUs leaving the boiler
 - To preheat boiler gas before pollution control
 - An economizer preheats primary or secondary air
 - An economizer is used to increase secondary superheat temperature
47. In some boilers coal is pulverized to _____
- increase the percentage of fuel surface area exposed to heat and oxygen
 - make it easier to transport to the furnace for burning
 - decrease the cost of furnace combustion equipment
 - decrease the amount of pollutants produced

48. Solenoid valves use _____ to operate.
- a. manual levers
 - b. pneumatic actuators
 - c. electro magnetism
 - d. electric motors
49. In the operation of a safety valve, the term "blow down" refers to
- a. the pressure at which the valve opens
 - b. the difference between valve opening and closing pressures
 - c. the pressure at which the valve closes
 - d. the volume of gas released by the valve when it is open
50. _____ can be found by multiplying volts and amps.
- a. Ohms
 - b. Hertz
 - c. Watts
 - d. Resistance

Appendix D: Sample Job Description Worksheet

DEPARTMENT OF THE ARMY JOB DESCRIPTION WORKSHEET FOR SUPERVISORS (or Statement of Major Changes to Job) For use of this form, see CPR 501.6; the proponent agency is ODCSPER.		PREPARED BY (Supervisor's Signature)
<input type="checkbox"/> NEW JOB (Complete all of Parts I and II)	<input checked="" type="checkbox"/> CHANGE TO JOB NUMBER <u>19579</u> (Complete Part I and Factors in Part II being changed)	NUMBER OF INCUMBENTS, IF ANY
Continue on plain bond paper, if necessary		
PART I - MAJOR DUTIES		
1. MAJOR DUTIES: (For change of existing job, explain which duties are changing, which remain the same, and for the new duties, "what" is done. For new job, describe "what" is done.) Suggested Title - Boiler Plant Equipment Mechanic 1. Serves as a boiler water analyst performing boiler water control work in approximately 53 steam generation/heating plants having total of 75 high/low pressure steam boilers. These boilers range from 45 to 500 horsepower, operate at pressures from 15 to 125 pounds per square inch gauge (psig), and generate 1000 to 35,000 pounds of steam per hour and may be active or idle on lay up. Collects and analyzes daily boiler water samples for specified chemical concentration. Diagnoses and prescribes required chemical treatment needed to return the boiler water chemical concentrations to specified ranges that will provide adequate scale and corrosion protection from dissolved oxygen and minerals or retest or retreat until chemical concentration and low pH are stabilized. Collects and analyzes cooling tower samples for (Continued on next page)		
PART II - FACTORS		
2. KNOWLEDGE/SKILL: (What procedures, work practices, regulations, processes, principles, sequences, equipment, tools, facts, and abilities are used? To what are they applied, for what purpose, and to what degree or level?) Must be knowledgeable of boiler water, cooling tower and dual temperature closed system treatment as it pertains to boilers, cooling towers and temperature closed system operations including steam and condensate lines. Tests range in complexity from routine to the highest difficulty. Must understand the expected results of chemical treatment, discover unexpected results and determine reasons for unexpected results by further testing, by applying knowledge of boiler plant functions, steam usage, and equipment relationship. Must have a working knowledge of chemistry, especially as applied to water and water make up. Must be able to read and understand blueprints and schematics as applied to chemical water, steam, condensate, and blowdown systems in boiler plant and related areas. Must have knowledge and skill to repair, troubleshoot and install large (Continued on next page)		
3. SUPERVISORY CONTROLS: (How is work assigned? What is the responsibility for carrying work out? How is work reviewed and by whom?) Receives verbal instructions, service orders or work orders from immediate supervisor and General Foreman outlining in general terms equipment deficiencies and extent of work to be accomplished. Supplemental instructions such as blueprints, sketches, specifications and special instructions are provided as necessary. Determines own work methods, plans sequence of work and is responsible for overall accomplishment using the full range of trade techniques and work methods. Work is spot checked during performance or upon completion for satisfactory workmanship.		

Job Description #19579

Major Duties (continued):

approximately 25 cooling tower systems ranging in size from 40 tons to 1200 tons capacity for regulating cycles of concentration based on conductivity or chlorides. Adjust chemical feed pumps and bleed rates continuously to maintain acceptable cycles.

a. Performs chemical analytical tests: Perform chemical analytical tests for sealing tendency, turbidity, hardness, alkalinity, free mineral acid, carbon dioxide, pH, sulfate, sodium sulfite, chloride, nitrate, glycol, sodium silica, iron, manganese, aluminum, oxygen, hydrogen sulfide, ammonia, dissolved solids, conductivity suspended solids and total solid or selected test as suitable to maintain stable chemical concentrations. Collects and analyzes water samples from chilled water, hot water and dual temperature heating and cooling systems, steam systems, steam condensate return systems and cooling towers systems for specified chemical concentration for the respective system. Diagnose and prescribe chemical treatment needed to return water in its respective system to proper chemical concentration. Collect and analyze water samples from the domestic water supplies for chlorine residuals.

b. Performs inspection tasks: Inspects piping, valves, tank, pumps associated with water condition system. Make standard corrosion test on condensate return systems and make required chemical treatments to reduce or eliminate corrosion problems in the piping systems.

Inspects boiler to determine the need for chemical cleaning. Performs qualitative and quantitative statistical analysis to establish trends, mean and standard deviations. Analyzes the statistical results for probable cause and variance.

c. Performs related tasks: Establishes boiler blowdown intervals or rates for manual or automated systems respectively. Adjusts bleed rates on cooling tower to maintain proper cycles of concentration (COC).

Maintains records to reflect daily test results and chemical added to water systems. Submits monthly reports as required by current regulations. Provides monthly water samples for quality assurance correlation testing. Secures needed laboratory chemical to conduct test. Maintains test equipment and work area

in clean and serviceable condition. Maintains, services and repairs all equipment with water conditioning systems. 55%

2 Repairs, troubleshoots and installs large complicated heating units and systems including oil and/or gas fired systems. Observes the tests of the operating heating systems in order to localize malfunctions in automatic controls, pumps and related components. Inspects, adjusts, and as necessary replaces or repairs thermostats, switches, fuel cutoff apparatus, burners, fuel feed, flame safeguard controls, ball bearing thrust bearings, drive rears, springs, gaskets and damaged parts and electronic and other safety devices. Remove burner, burner nozzle, strainer and orifice assemblies; dismantles and locates defects; reassembles and reinstalls components. Services unit by cleaning filters, strainers, orifices, ignitions electrodes and adjusting dampers. Removes soot and fly ash from tubes, chamber ducts, chimneys and breechings. Installs new heating plants, hot water boilers furnaces, pumps, controls and connects new equipment to existing facilities. Repairs motorized and gas diaphragm valves to include replacing gaskets and diaphragm; repacking motorized valves to prevent leakage around needle valve; and cleaning and adjusting gas valves to free the operating plunger. Serves as emergency "no heat" mechanic. Responsible for operation and maintenance of high pressure boiler plants. Operates gas, oil fired boiler plants with all pounds of steam per hour. Maintains proper steam pressure of water temperature at all times by adjusting controls and regulating auxiliary equipment. Cleans fire tubes and blows down boilers. Synchronizes boilers when switching from one boiler to another to avoid loss of steam pressure. Operates and adjusts auxiliary plant equipment. Inspects boilers and equipment in accordance with prescribed schedule and check list. Makes adjustments and repairs to plant and auxiliary equipment, reporting evidence of deficiencies requiring major overhaul and repair. Maintains operating log, recording pertinent information concerning operation and maintenance, i.e., fuel, BTU output and plant efficiency.

Performs refrigeration and air conditioning maintenance tasks. Works in the disassembly and repair of heavy and complicated industrial and domestic types of refrigeration and air conditioning equipment. Representative tasks include cutting and threading pipe and coil lengths; replacing piston rings, bearing, connecting rods, pins, crankshafts, belts, valves, gaskets, and other similar parts; connects or disconnects wiring and lines; solders and brazes tubing; charges and/or purges refrigeration

units. Removes old and installs new equipment. Units and systems services are designed requiring few testing techniques to locate worn or broken parts; repairs are not normally complicated by need for specialized equipment. 45%

Performs other duties as assigned.

1. Knowledge/Skill (continued):

complicated commercial and industrial heating units and systems. Requires thorough knowledge of principles of methods of combustion, ratios and arrangements of heating surfaces, distribution and construction of large complex heating units and systems. Skilled in completing complex repair/replacement procedures. Knowledge and skill to observe, test heating equipment, localize malfunctions and determine and carryout action necessary to correct malfunction. Utilizes pipefitter/plumber mechanic skills in repair of gauges, heaters, tests instruments, probes use in water measuring and testing and electrical knowledge of semiautomatic boiler firing and control devices, limiting and safety switches, pumps, heaters and meters. Uses mathematics on a continuing basis employing percentage, ratios, measuring units, laboratory terms and metric measurements.

2. Responsibility:

Works under very general supervision of immediate supervisor and the General Foreman, Climate/Kitchen Equipment Shop. Receives verbal instructions, service orders or work orders outlining in general terms equipment deficiencies and extent of work to be accomplished. Independently performs duties in accordance with established procedures, technical manuals and manufacturer's specifications. Is responsible for taking boiler water, cooling tower, and closed system samples and providing chemical treatment to maintain boilers, cooling towers and dual temperature closed system. Determines if unexpected results from tests are caused by system malfunctions. Supervisor reviews work in terms of boiler, cooling tower, and dual temperature closed system condition and results of treatment as reported by boiler inspector and visual inspections. Supplemental instructions such as blueprints, sketches, specifications are provided as necessary. Determine own work methods, plans sequence of work and is responsible for overall accomplishment using full range of trade techniques and work methods. Work is spot checked during performance or upon completion for satisfactory workmanship.

II. Factors (continued):

3. Physical Effort:

Work involves frequent lifting, loading and carrying heating equipment parts and chemical containers weighing up to 100 pounds, operating hoists, holders, hand trucks and pulleys when replacing parts or mixing and transporting chemicals. Work also involves working or walking on wet, slippery surfaces, climbing on and working or walking from high ladders, scaffolds and platforms. Working in cramped areas, crawling into boilers and up and around cooling towers. Incumbent is required to stoop, bend, stretch, kneel and work in tiring and uncomfortable positions.

4. Working Conditions:

Works in chemical laboratory and boiler rooms on concrete floors subject to relatively high temperature and is exposed to gas, carbon monoxide, smoke, ash, dust, fumes and burns from scalding water, boiler explosion hazards and contact with heated parts of the system. Subject to injuries from falls, dropping moderately heavy items, chemical burns, loud, constant noise and use of hand tools. Subject to exposure to hazardous chemicals such as algaecide, oxidizers and caustics. Frequently must wear protective clothing and devices such as goggles, respirators, heavy aprons, hard hats and gloves and occasionally works outside or in cramped quarters.

5. Certifications:

Must possess a valid non-commercial drivers license to operate vehicles to transport tools and equipment to service heating and cooling equipment. Must possess a valid power engineers license corresponding to the size and complexity of heating and cooling equipment operated.

Appendix E: Fourth Class Power Engineer Course Schedule

The course should cover the topics listed in the NIULPE Fourth Class Power Engineer Curriculum. The NIULPE topics are grouped together with a suggested lecture title and lecture time. The number in brackets are the specific learning standards from the NIULPE Curriculum. The only learning objective not mentioned by name in the NIULPE standard is the training on the legal requirements pertaining to boiler operations on DOD installations. The instructor should refer to the applicable ASME Boiler Code articles.

Fourth Class Power Engineer Curriculum:	
Topic	Lecture Hours
Boiler Features (1 to 9)	5
Boiler Grates and Burners (21 to 23)	1.5
Combustion and Pollution (16,34)	1.5
Boiler Controls (33)	1.5
Feedwater, Corrosion and Water Treatment (11 to 14)	1.5
Pumps and Injectors (17,18)	1.5
Steam System and Steam Piping (24,30,31)	1.5
Boiler Operations and Maintenance (10,19,20)	2
Mathematics (15)	1.5
Electricity (27)	2.0
Air Conditioning, Refrigeration and Air Compressors (25,26,32)	3
Safety (35)	1.5
Logs, Log Review, Inspections and Regulations	1.5
Total	24.5

Overall Program Time Budget:	
Administration	2 hours
Lectures	24.5 hours
Tours	1 hour
Video Presentation	1 hour
Review	8 hours
NIULPE testing	3.5 hours
Total	40 hours

Below is a recommended program schedule. The schedule was based on using 4.5 days to conduct a class and 0.5 days to administer a NIULPE examination. The amount of time devoted to the various topics was based on our observation of operator performance on the exam and operator feedback from interviews in previous pilot courses. It is recommended some of the more difficult topics such as electricity and refrigeration equipment be covered early in the course to afford the instructor opportunity to conduct extra review or to allow operators time to study on their own if needed.

Sample Schedule:

Time	Monday	Tuesday	Wednesday	Thursday	Friday
8:00	Admin	AC & R	Comb/Poll	Review	Review
8:30	Pre-Test	AC & R	Comb/Poll	Review	Review
9:00	Pre-Test	AC & R	B. Controls	Steam/Pipe	Post-Test
9:30	Math	AC & R	B. Controls	Ops/Maint	Post-Test
10:00	Math	AC & R	B. Controls	Ops/Maint	Review
10:30	Math	AC & R	FeedW/Chem	Ops/Maint	Review
11:00	Elect	B. Features	FeedW/Chem	Ops/Maint	Review
11:30	Elect	B. Features	FeedW/Chem	Safety	Review
12:00	Lunch	Lunch	Lunch	Lunch	Lunch
13:00	Review	Review	Review	Review	NIULPE
13:30	Elect	Tour	Video	Video	NIULPE
14:00	Elect	Tour	Pump/Inj	Safety	NIULPE

Time	Monday	Tuesday	Wednesday	Thursday	Friday
14:30	B. Features	Grate/Brnr	Pump/Inj	Safety	NIULPE
15:00	B. Features	Grate/Brnr	Pump/Inj	Logs/Regs	NIULPE
15:30	B. Features	Grate/Brnr	Steam/Pipe	Logs/Regs	NIULPE
16:00	B. Features	Comb/Poll	Steam/Pipe	Logs/Regs	NIULPE
16:30	Review	Review	Review	Review	Admin
Legend: B. Features Boiler Features Grate/Brnr Boiler Grates and Burners Comb/Poll Combustion and Pollution B. Controls Boiler Controls FeedW/Chem Feedwater, Corrosion and Water Treatment Pump/Inj Pumps and Injectors Steam/Pipe Steam System and Steam Piping Ops/Maint Boiler Operations and Maintenance Elect Electricity AC & R Air Conditioning, Refrigeration and Air Compressors Logs/Regs Logs, Log Review, Inspections and Regulations					

Appendix F: NIULPE Fourth Class Power Engineer Curriculum

A Curriculum to Cover the Basic Fundamentals shall include:

1. Water glass: Placement, function, how held in place, length, maintenance, valves needed, replacement, how and when tested.
2. Water column: Placement, function, how held in place, length, care, what could affect its efficiency, maintenance, valves and cocks needed, how and when tested.
3. Safety valve and rupture discs: Placement, function, care, maintenance, how and when tested, description, potential failures, adjustment for pressure.
4. Steam gauge and siphon: Placement, principle, function, care, maintenance, potential failures, how and when tested.
5. Feed water, piping and valves: Location, care, maintenance, potential failures. Reason for valves on piping, how kept in good condition. Reason for internal pipe.
6. Blow down valves, piping and tank: Location, purpose, potential failures, care.
7. Fusible plug: Where placed, purpose, how kept in good condition, possible failures, description. Installation, when renewed.
8. Stays: Placement, purpose, types, description, care advantages of various types, potential failures.
9. Two common types of boilers-fire tube and water tube: Description and characteristics. Qualities of good boiler.
10. Dangerous conditions: When a boiler should not be operated. Causes of boilers being burned or exploded.
11. Corrosion, pitting, priming and foaming, bulging, bagging: Meaning of each, where found and how created, dangers and remedies.
12. Scale and mud: Where found, cause, prevention, effect, dangers, removal.
13. Feed water treatment: Meaning, purpose, how applied and controlled, dangers of over-treatment and under-treatment.
14. Feed Water heaters: Types, purpose, advantages, methods of heating feed water, applications, potential failures.
15. Mathematics: A knowledge sufficient to solve any simple problem involving division and multiplication.

16. Elementary combustion: Mixtures of combustibles and air, methods of application and how controlled, purpose of setting, dampers, draft, chimneys or stacks, hand firing methods, heating values of anthracite or bituminous coal, oil and gas.
17. Pumps-simplex, duplex, vacuum: Care, maintenance, purpose, potential failures, remedies, description.
18. Injector: Function, principle, care, maintenance, cleaning and inspection, how often, purpose, valves.
19. Cleaning and inspection of boilers and setting.
20. Starting clean boiler: Manhole covers, how replaced and removed, raising steam, cutting into live steam header, banking boiler and starting after bank.
21. Grate surface, fire line, water level, fire tubes, water tubes, heating surface: Meaning of these terms.
22. Operation of stoker: Starting, purpose, maintenance, care, potential failures, advantages and disadvantages.
23. Operation of oil or gas burners and electric boilers: Installation, starting, care, possible failures, controls, safety devices.
24. Steam non-return valve, expansion joints, heaters, steam separator, sight feed lubricator, steam trap reducing valve, feed water regulator: Function, use and location.
25. Refrigeration compressor, condenser, receiver, evaporator, purge, expansion valve, charting, liquid, suction, discharge, cross-over valves: Purpose, location, dangers, correct operating procedures.
26. Air compressor: Dangers in operation, maintenance, correct operating procedure.
27. Electrical equipment: Fuses, cut outs, relays, switches, circuit breakers, purposes and comparative applications. Dangerous conditions in operation of a motor. Prevention of starting. Sizes of fuses. Carrying capacities of wires for lighting circuits. Volt, ampere, watt, Ohm, D.C., A.C., electrical conductor, electrical insulator: Meaning of these terms. Difference between electric generator and motor.
28. Steam Engines: Types, setting valves, purpose of fly wheel, eccentric, governor, cross head, lead, lap, angle of advance, valve travel and cut off, methods of lubrication and application to various parts, how started and how shut down, maintenance and care.
29. Steam turbines: General knowledge of the lubricating system, governors, and throttle valves.
30. Steam condensers: General knowledge of condensers, where, how and why they are used. General care and upkeep of condenser auxiliaries.
31. Steam plant accessories: Back pressure valves, non return valves, throttle valves, expansion joints, feed water regulators, steam separators, sight feed lubricators,

steam traps, reducing valves, sprinkler systems, function, location, operation and care.

32. Heating, air conditioning and ventilation: Methods, controls, meaning of water hammer, piping arrangements, radiation, vacuum and plenum systems in mechanical ventilation, gravity and vacuum steam systems. Maintenance.
33. Operation and maintenance of controls.
34. Air pollution and ecology.
35. Plant safety.

Appendix G: Fourth Class Power Engineer Study Guide

Below is the NIULPE Curriculum and the locations in the complete NAPE library that address those topics. The numbers refer to the NAPE publication number that contains the topic information. Please note that **NAPE publication numbers 1, 2, 15, 16, 19 and 22 are bound together** for the operator's convenience in a book named "National Association of Power Engineers (NAPE) Boiler Operator Course and Certification Study Questions." This single book should provide a reasonable substitute for access to the whole NAPE library. Feel free to copy this list and distribute it to your operators.

NIULPE

Topic

Suggested NAPE Library

Number Publication Number and Page Numbers

1. **Water glass:** Placement, function, how held in place, length, maintenance, valves needed, replacement, how and when tested.
 22: p.8; 25: Lesson 6, p.14-22; 26: p.31-33; 27: p.25-29,30;
 30: p.227-233
2. **Water column:** Placement, function, how held in place, length, care, what could affect its efficiency, maintenance, valves and cocks, how and when tested.
 22: p.7,8; 25: Lesson 6, p.14-22; 26: p.31-33; 27: p.25-29,181;
 30: p.227-233,296
3. **Safety valve and rupture discs:** Placement, principle, function, care, maintenance, potential failures, how and when tested.
 1: question 13; 15: questions 79,116,117,198
 16: Elem. questions 5,8; 19: questions 46,59,60 22: p.8,28
 25: Lesson 6, p.9-14; 26: p.22-27,41,42,182;
 27: p.21-24; 30: p.243-252,284,305,502-504,565

4. **Steam gauge and siphon:** Placement, principle, function, care, maintenance, potential failures, how and when tested.
15: questions 60,66,148; 16: Elem. question 7 19: questions 50,59,60
22: p. 8,17
25: Lesson 6, p.4-8; 26: p.27-31;
27: p.28-30; 30: p.235-237
5. **Feed water, piping, and valves:** Location, care, maintenance, potential failures. Reason for valves on piping, how kept in good condition. Reason for internal pipe.
15: questions 35,130,173,215; 19: questions 64,65,76,77; 22: p.15
25: Lesson 7, p.2-5; 26: p.50-54;
27: p.72-78,51,52; 30: p.289-290
6. **Blow down valves, piping and tank:** Location, purpose, potential failures, care.
15: question 120; 16: Elem. questions 2,4; 19: questions 31,67,68,70;
22: p.7; 25: Lesson 2, Lesson 7 p.5-13;
26: p.33-34; 27: p.37-39; 30: p.252-256,573-574
7. **Fusible plug:** where placed, purpose, how kept in good condition, possible failures, description. Installation, when renewed.
15: question 57; 19: questions 48,72;
25: Lesson 2 p.5, Lesson 7 p.1;
26: p.39-40,155,159; 27: p.20; 30: p.233-235,316
8. **Stays:** Placement, purpose, types, description, care advantages of various types, potential failures.
19: question 35; 22: p.7; 25: Lesson 5 p.8-13; 27: p.12-13; 30: p.83-84
9. **Two common types of boilers - fire tube and water tube:** Description and characteristics. Qualities of good boiler.
1: questions 2,3,4,43; 15: questions 20,55,140,246;
16: Elem. question 9; 19: questions 1,3,4,5,7,17,19,20,29,42; 22: p.6
25: Lesson 1, Lesson 2, Lesson 3 p.10, Lesson 4;
26: p. 13-19; 27: p.2-11; 30: p.1-19

10. **Dangerous conditions:** When a boiler should not be operated. Causes of boilers being burned or exploded.
16: Elem. question 12; 22: p.8; 26: p. 33,60,65,154,155,192
11. **Corrosion, pitting, priming and foaming, bulging, bagging:** Meaning of each, where found and how created, danger and remedies.
1: question 69; 16: Elem. questions 3,10; 19: question 37; 22: p.13;
25: Lesson 12 p.5; 26: p. 38,142,183; 27: p.170-172;
30: p.29,31,109,290-294,303,316
12. **Scale and mud:** Where found, cause, prevention, effect, dangers, removal.
19: question 41; 22: p.29; 26: p. 35,36,40,59,138,139,143,149,185;
27: p.37,68,170; 30:p.289,293,297,309
13. **Feed water treatment:** Meaning, purpose, how applied and controlled, dangers of over-treatment and under-treatment.
1: questions 69,70,71,73; 19: questions 100,101,102,103,104
26: p.139-143; 27: p.170-176;
30: p.289-296,567-571,557,559-561
14. **Feed water heaters:** Types, purpose, advantages, methods of heating feed water, applications, potential failures.
15: questions 170,191,67,68; 19: questions 47,93,94,95,97;
22: p.14,15,37;
26: p.139; 27: p.68-72; 30: p.91,557-567
15. **Mathematics:** a knowledge sufficient to solve any simple problem involving division and multiplication.
1: questions 51,52; 8: p.1-11; 15: question 10
25: Lesson 1, p.13-17, Lesson 2, p.16-21, Lesson 3, p.12-16
16. **Elementary combustion:** Mixtures of combustibles and air, methods of application and how controlled, purpose of setting, dampers, draft, chimneys or stacks, hand firing methods, heating values of anthracite or bituminous coal, oil and gas.
1: questions 27,107; 4: p.1-13; 15: questions 155,156,171,183,231;
16: Elem. questions 19,20,21, Inter. question 17;
19: questions 108,113,114,117,183,184,185,186,187,192; 22: p.18,19,27
25: lesson 12; 26: p.116-118; 27: p.123-131; 30: p.99-120,122,123,216

17. **Pumps - simplex, duplex, vacuum:** Care, maintenance, purpose, potential failures, remedies, description.
15: questions 27,98; 16: Inter. question 7;
19: questions 353,355,362,365,366,368,370,374,377,378,385,389,390,391,393,395; 22: p.10,13,14,37
27: p.95; 30: p.327-381
18. **Injector:** Function, principle, care, maintenance, cleaning and inspection, how often, purpose, valves.
15: question 80; 22: p.18 30: p.328-330
19. **Cleaning and inspection of boilers and setting:** Basics.
16: Elem. question 11; 19: questions 36,71; 22: p.8,29;
25: Lesson 5 p.16, Lesson 13; 26: p.157-159; 27: p.187-188;
30: p.314-317
20. **Starting clean boiler:** Manhole covers, how replaced and removed, raising steam, cutting into live steam header, banking boiler and starting after bank.
22: p.38 25: Lesson 13; 26: p. 150-152; 27: p.183-187; 30: p.283-286
21. **Grate surface, fire line, water level, fire tubes, water tubes, heating surface:** Meaning of these terms.
15: questions 212,213; 16: Elem. questions 6,23, Inter. question 4;
19: questions 1,2,38,39,44,150; 22: p.8,18,28;
25: Lesson 1 p.4, Lesson 5 p.14; 26: p.2,3; 27: p.100-103; 30: p.147-178
22. **Operation of stoker:** Starting, purpose, maintenance, care, potential, failures, advantages and disadvantages.
15: question 212; 16: Elem. question 22; 19: questions 129,131,132,133,137,138,145,146,152,157,175;
26: p.109-115; 27: p.100-104; 30: p.51-54,148-178
23. **Operation of oil and gas burners and electric boilers:** Installation, starting, care, possible failures, controls, safety devices.
6: p.1-30; 19: questions 125,441;
26: p. 93-104; 27: p.90-100,128,180;
30: p.9,180,189-191,199-212

24. **Steam non-return valve, expansion joints, heaters, steam separator, sight feed lubricator, steam trap reducing valve, feed water regulator:** Function, use and location.
1: question 9; 19: questions 61,62,63,73,107,431,432,433,435;
22: p.15,28
25: Lesson 7 p.13-18; 27: p.31-32,37,77,81-84,93-94;
30: p.237-243,256-261,444,575,589-592
25. **Refrigeration compressor, condenser, receiver, evaporator, purge, expansion valve, charging, liquid, suction, discharge, cross-over valves:** Purpose, location, dangers, correct operating procedures.
3: p.4-28; 5: p.10-17;
15: questions 41,123,220; 16: Elem. questions 17,18; 31: p. 73-140
26. **Air compressor:** Dangers in operation, maintenance, correct operating procedure.
15: question 174; 16: Inter. question 13;
19: questions 448,452,454,460,462,467,472,490,494,499
27. **Electrical equipment:** Fuses, cut outs, relays, switches, circuit breakers, purposes and comparative applications. Dangerous conditions in operation of a motor. Prevention of starting. Sizes of fuses. Carrying capacities of wires for lighting circuits. Volt, ampere, watt, Ohm, D.C., A.C., electrical conductor, electrical insulator: Meaning of these terms. Difference between electric generator and motor.
2: questions 1,3; 15: questions 22,49,71,127,135,185,196,235,254;
16: Elem. questions 1,25
23: Lessons 3-22; 29: p. 21-43
28. **Steam engines:** Types, setting valves, purpose of fly wheel, eccentric, governor, cross head, lead, lap, angle of advance, valve travel and cutoff, methods of lubrication and application to various parts, how started and how shut down, maintenance and care.
16: Elem. questions 14,15; 19: questions 205,225,419,420; 22: p.22,23;
30: p.385-473

29. **Steam turbines:** General knowledge of the lubricating system, governors and throttle valves.
14: p.1-6; 15: question 64; 19: questions 255, 256, 257, 259, 268, 270, 272, 280, 281, 295, 296, 302, 320; 22: p.25, 39; 30: p.473-525
30. **Steam condensers:** General knowledge of condensers, where, how and why they are used. General care and upkeep of condenser auxiliaries.
15: questions 236,237; 19: questions 304,316,322,342;
30: p.505-524, 539-551
31. **Steam plant accessories:** Back pressure valves, non-return valves, throttle valves, expansion joints, feed water regulators, steam separators, sight feed lubricators, steam traps, reducing valves, sprinkler systems, function, location, operation and care.
1: questions 62,63; 15: question 36; 19: questions 61, 62, 63, 75, 76, 96, 107, 428, 429, 430; 26: p.49-83; 27: p.67-89; 30: p.237-243, 256-273, 557-602
32. **Heating, air conditioning and ventilation:** Methods, controls, meaning of water hammer, piping arrangements, radiation, vacuum and plenum systems in mechanical ventilation, gravity and vacuum steam systems. Maintenance.
5: p.1-21; 15: questions 101, 114, 217; 31: p.641-799
33. **Operation and maintenance of controls:** Basics.
19: questions 77,78,79
26: p.118-136; 27: p.137-152;
30: p.273-280
34. **Air pollution and ecology:** Basics.
15: questions 169,193; 27: p.162; 30: p.603-633
35. **Plant safety.**
15: question 196; 19: question 499; 26: p.191-199; 27: p.192-196

Appendix H: Sample CHPTUTOR Software Architecture

CERTEST is a computer-based testing tool developed by the U.S. Air Force Space Command to measure the knowledge level of base facility support personnel. The CERTEST software could be modified to perform as a computer based tutoring tool. Figures H1 and H2 show some typical user interfaces screens from a NIULPE test module written for CERTEST.

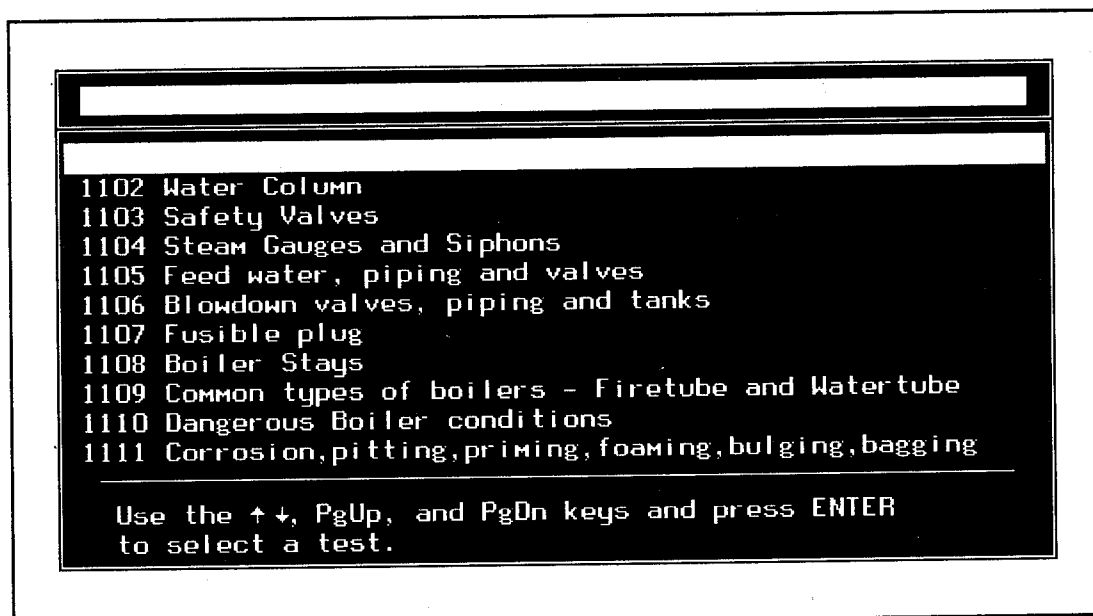


Figure H1. Sample of test selection screen.

Test Number and Title	Status	%	Last Taken
PRETEST	N	-	-
1101 Water Glass	P	100	08 Jun 93
*1102 Water Column	P	100	08 Jun 93
1103 Safety Valves	N	-	-
1104 Steam Gauges and Siphons	N	-	-
*1105 Feed water, piping and valves	P	100	06 Dec 93
1106 Blowdown valves, piping and tanks	N	-	-
1107 Fusible plug	N	-	-
1108 Boiler Stays	N	-	-
*1109 Common types of boilers - Firetube and Watertube	P	83	06 Dec 93
1110 Dangerous Boiler conditions	F	0	30 Aug 93

* = test locked, see your supervisor for access.
 P = Passed
 N = Needed
 F = Failed
 ✓ = Tested Out
 ■ = Tests Imported

ESC to previous menu.

Figure H2. Sample test manager screen.

Appendix I: CHPTUTOR Draft Proposal

RESEARCH PROPOSAL TITLE: Central Heating Plant Computer Guided Tutoring System (CHPTUTOR) - System Requirements, Structure and Development Plan.

1. **STATEMENT OF PROBLEM:** The variety of equipment found in typical Department of Defense (DOD) central energy plants and the complexity of the overall operation and maintenance of these plants demands that the operators be highly qualified personnel. In order to increase the safety and reduce the energy and environmental cost of operating DOD central energy plants, a DOD wide operator training and certification program needs to be developed and implemented. Industry has recognized the need for standardizing training and certification of central heating personnel for over 20 years with the establishment of the National Institute for the Uniform Licensing of Power Engineers (NIULPE). Development of a mechanism to take advantage of current DOD and industry training resources to guide the operator's study efforts would greatly assist in meeting the requirement of operator training certification. There is also a professional development requirement for many DOD operators to complete curriculum that partially fulfills accepted operator certification standards. It is highly desirable that any operator certification training program complement current DOD study programs instead of compete with them.

2. **REFERENCE:** The tri-services working group meeting on the Certification and Training of Central Heating Plant Operators held at Fort Belvoir, VA on 19-20 May 1992 has identified a need for training systems for central heating plant operators. The working group expressed an interest in utilizing existing systems and standards to meet this training need. The U.S. Air Force CERTTEST System was singled out as being a good product that could be modified into a tutoring tool.

3. **OBJECTIVE OF PROJECT:** The final product will be a computer based tutoring system to prepare central heating plant operators and supervisors for certification. The system will generate study questions for each curriculum subject necessary for a particular class of certification. The design of the question bank must have the flexibility to be addressed by the NIULPE curriculum and at least two other similar training curriculums such as USAF Career Development Courses (CDC) or US Navy Personnel Qualification System (PQS). The ability to track progress in similar

training programs will increase training productivity since multiple training goals will be met with a single effort. The question bank will also have sufficient flexibility to direct the student to the precise location in a training resource for corrective study. Additionally, the system's ability to track multiple training objectives and precisely direct the operator's study effort will allow use of this product with other existing DOD training curriculums. Successful utilization of this product may warrant its use with other DOD or industry training programs.

4. **APPROACH:** This product will be an adaptation of the existing USAF testing aid CERTEST. The question bank architecture will be expanded to provide flagging for access by multiple curriculums and to provide documentation of the location(s) of the correct answer. The curriculum manager will have screen options added to assist in editing and creating curriculums and tutorial programs.

TASK I - DRAFT SYSTEM ARCHITECTURE: A schematic will be developed of the tutoring system. The structure will be checked for compatibility with the existing CERTEST system so that modifications can be identified. The structure will be compared with the NIULPE curriculum, the USAF CDC 54550 series curriculum and at least one other curriculum or training standard currently used in DOD.

TASK II - CERTIFICATION TRAINING CURRICULUM DOCUMENTATION: The current NIULPE and CDC curriculum and study questions will be reviewed. Questions and question references will be selected for inclusion in the training system. The questions will be constructed to meet the format requirements of the training system. Copyright permissions will be secured as necessary.

TASK III - DRAFT USER AND MANAGER INTERFACE: Diagrams and schematics of student and curriculum manager interfaces will be produced. Screen representations will be chosen to meet the interface requirements. The following interface requirements should be met:

Student:

The ability to view overall progress across all curriculum enrolled in.

The ability to view overall progress across all certification levels or CDC books.

The ability to view progress within a certification level or CDC book.

The ability to view progress within a certification knowledge area or CDC book chapter.

Printout a listing of weak knowledge items and precise locations of the correct answer.

Legible question screen with graphic representation possible.

Receive immediate feedback on wrong answers and information on where to find the correct answer.

The ability to mark a question that may be wrong or ambiguous so that the test manager can review that question.

The ability to submit draft questions to the test manager for review and possible inclusion in the test bank.

Recording of progress in multiple curriculum with the completion of a single question.

The ability to access CD-ROM reference materials while in the CHPTUTOR

Manager:

The ability to view overall progress across all curriculum for an individual and a group.

The ability to view overall progress across all certification levels or CDC books for an individual and a group.

The ability to view progress within a certification level or CDC book for an individual and a group.

The ability to view progress within a certification knowledge area or CDC book chapter for an individual and a group.

Print out a listing of weak knowledge items and precise locations of the correct answer for an individual.

Legible question screen with graphic representation possible.

The ability to add, delete or edit locally produced questions.

The ability to flag erroneous force produced questions so that the system will not call on the question.

The ability to mark a question that may be wrong or ambiguous so that the force test manager can review that question.

The ability to submit draft questions to the force test manager for review and possible inclusion.

The ability to add references for all questions.

The ability to specify access to a CD-ROM reference for all questions.

The ability to add, edit or delete references for local questions.

The ability to import an updated force question bank or new force curriculum to the system.

The ability to import local questions from other bases into the local question bank.

Menu access to the standard flags so that locally produced questions are compatible force wide if approved.

The ability to add or delete flags to local questions when viewing a question.

The ability to add flags to any current question when viewing a question.

The ability to view a list of a test or test section.

The ability to assign a descriptive label to a locally produced question so that the entire question list may be viewed.

The ability to view the entire question list by sort or sorted view options.

The ability to access a question from a list.

The ability to view the flagging options of a particular question or group of questions while viewing a question list.

The ability to add or delete flags to a particular question or group of locally produced questions while viewing a question list.

The ability to view the question selection criteria when viewing the list of a test or test section (i.e., 2 of 6 questions will be chosen).

The ability to print out tutorial questions.

The ability to assign descriptive names to augment the alphabet letter test section name.

TASK IV - ALPHA VERSION STRUCTURE DEVELOPMENT: The first system version to meet the specifications of TASK I, TASK III and paragraph 5 will be developed.

TASK V - ALPHA VERSION QUESTION BANK LOADING: The technical information for at least four (4) NIULPE curriculum topics, a NIULPE simulated test and one (1) chapter of a heating USAF CDC will be loaded into the program structure.

TASK IV - ALPHA VERSION TESTING: The prototype system will be tested at a minimum of two (2) DOD installations. The test program at each base will consist of at least the following:

- a. Five (5) operators will be briefed on the use of the system and will complete at least two (2) modules and a final test. Each of the operators will enter a draft question proposal and erroneous question alert for the local test manager.
- b. Five (5) operators will not be briefed but will be given only a draft guide booklet and will complete at least two (2) modules and a final test without any briefing or coaching. Each of the operators will enter a draft question proposal and erroneous question alert for the local test manager
- c. One (1) local test manager will be briefed on the use of the system and will add, edit and delete local questions provide by USACERL. The local test manager will also be given a simulated force update disk to load into the system. The local test manager will input proposed questions to the force manager for review. The local test manager will view all the manager screens and offer comments.

- d. One (1) local test manager will not be briefed but will be given only a draft guide booklet and will add, edit and delete local questions provide by USACERL. The local test manager will also be given a simulated force update disk to load into the system. The local test manager will input simulated proposed questions to the force manager for review. The local test manager will view all the manager screens and offer comments. The manager will conduct these procedures without any coaching.
- e. A simulated force test manager will review proposed force question bank additions or corrections and will make the changes, additions and deletions required.
- f. One local test manager will send some of his local question to the other local test manager. The receiving local test manager will install the imported questions and adjust the flagging of those questions.

TASK VII - ALPHA VERSION CRITIQUE: The comments and observations produced in TASK VI will be reviewed and collated into an interim report. Recommendations will be developed for implementation in the Beta version of the system.

TASK VIII - BETA VERSION DEVELOPMENT: The recommendations developed from TASK VI and TASK VII will be incorporated into the system structure.

TASK IX - BETA VERSION TEST BANK LOADING: The curriculum questions selected and developed in TASK II will be inserted into the system. If the modifications occurring in TASK VIII allow, the question bank loading can be concurrent with the beta version developments.

TASK X - BETA VERSION TESTING: The prototype system will be tested at a minimum of two (2) DOD installations. The test program at each base will consist of at least the following:

- a. Approximately one third (1/3) of the operators will be randomly tasked to take a pre-test similar in scope to the NIULPE Fourth Class Power Engineer examination prior to delivery of the system to establish a knowledge benchmark.
- b. The system will be shipped the bases for utilization. The bases will be given a time period of twelve (12) weeks to use the system.
- c. At the end of the trial period a post-test will be given to the same operators who took the pre-test to measure knowledge base increase.
- d. At the end of the trial period all the operators will be given the NIULPE Fourth Class Power Engineer examination. The pre-test and post-test participant's performance will be segregated to measure any bias since they had extra test taking experience.

- e. At the end of the trial period all the operators at one (1) similar non-participating base will be given a NIULPE examination to provide a control sample group.
- f. Interviews will be conducted at the participating bases to obtain feedback of the system's performance.

TASK XI - BETA VERSION CRITIQUE: The comments and observations produced in TASK X will be reviewed and collated into an interim report. Recommendations will be developed for implementation in the Gamma (final) version of the system.

TASK XII - GAMMA (FINAL) VERSION DEVELOPMENT: The recommendations developed from TASK X and TASK XI will be incorporated into the system structure.

TASK XIII - GAMMA VERSION TEST BANK LOADING: The curriculum questions selected, developed and loaded in TASK II and TASK IX will be inserted into the system. If the modifications of TASK XII allow, the question bank used for the beta testing can be loaded into the gamma version. Question content modifications necessary based on comments in TASKS V, VI, X and XI will be implemented as well.

TASK XIV - GAMMA VERSION DELIVERY AND FINAL REPORT: The gamma version will be delivered to the bases as specified by each of the services within DOD. A final report will be produced documenting the work conducted in TASKS I to XII. Recommendations for other applications of this system within the DOD will be included in the report.

5. PRODUCT OF RESEARCH: The final product will be a computer based tutoring system to prepare central heating plant operator and supervisor for certification. The system will generate study questions for each curriculum subject necessary for a particular class of certification. The design of the question bank must have the flexibility to be addressed by at least two other similar training curriculums such as USAF Career Development Courses (CDC's) or USN Personnel Qualification System (PQS). The ability to track progress in similar training programs will increase training productivity multiple training goals will be met with a single effort. The final product will have a question bank to address (5) five levels of certification similar to the certification levels designated by the National Institute for the Uniform Licensing of Power Engineers (NIULPE).

Specifications:

- a. Interfaces and capabilities described in TASK III.
- b. The identity of the student would be consistent across all curricula
- c. Two levels of test manager, local and force.

- d. Two test banks, force and local.
- e. Two types of question banks, secure and unreferenced (CERTEST), and, tutorial and referenced (CHPTUTOR)
- f. Three tiered system structure similar to CERTEST

Example:

CERTEST	NIULPE	USAF CDC
Shops	Operator Class	CDC Book Volume
Tests	Curriculum Knowledge Area	CDC Book Chapter
Section	Knowledge Goals	CDC Knowledge Objectives

- g. At least 3 curriculum flags on a question, NIULPE, CDC, and one reserved for future use. The question structure should have sufficient flexibility to add a fourth flag without major system reconfiguration.
- h. Each "test" module should be small enough to complete in 15-20 minutes.
- i. Completion of a question shared by multiple curricula would be recorded on each curriculum list in the student's record of progress file.
- j. The test question should tell the operator he was wrong and refer the operator to a publication to find the right answer. It should not tell the operator the right answer. It should allow the operator to access a CD-ROM reference document while in the tutorial.
- k. The study questions should come from NIULPE, National Association of Power Engineers (NAPE), USAF CDC and other DOD training materials.
- l. User's guide book.
- m. Local test manager's guide book.
- n. Force test manager's guide book.

6. COST ESTIMATE: TBD

TASK

EXPENDITURES

7. COMPLETION TIME:

The final task, TASK XIV, will be commence 15 months after the award of the contract.

8. POINT OF CONTACT: The USACERL technical point of contact for this project is Ralph Moshage and Michael Brewer, WATS (800) USA-CERL Ext. 5544/5544, or Commercial (217) 398-5507/5507, e-mail: moshage%fep@aardvark.cecer.army.mil or brewer%fep@aardvark.cecer.army.mil. The mailing address is Energy and Utility Systems Division, P.O. Box 9005, Champaign, IL 61826-9005.

Appendix J: Qualifications Needed for NIULPE Certification

Fourth Class Engineer	
Criterion	Qualification
Minimum age	18
Education required	2 years high school, 2 years approved apprenticeship, or approved OJT
Experience required	2 years minimum examination required-oral, written, practical maximum engine (prime mover) horsepower requiring licensed power engineer (unsupervised)-500 HP
Maximum boiler horsepower requiring licensed power engineer (Unsupervised)	LP-150 HP; HP - 25 BHP
Refrigeration license (unsupervised)	100 tons

Third Class Engineer	
Criterion	Qualification
Minimum age	20
Education required	High school grad. or GED, three years approved apprenticeship, or approved OJT
Experience required	3 years minimum
Examination required	Oral, written, practical
Minimum time in previous grade	1 year
Maximum engine (prime mover) horsepower requiring licensed power engineer (unsupervised)	1000 HP
Maximum boiler horsepower requiring licensed power engineer (unsupervised)	LP-unlimited; HP-200 BHP
Refrigeration license (unsupervised)	500 tons

Second Class Engineer	
Criterion	Qualification
Minimum age	21
Education required	High school, four years approved apprenticeship or approved OJT
Experience required	4 years minimum
Examination required	Oral, written, practical
Minimum time in previous grade	1 year
Maximum engine (prime mover) requiring licensed power engineer (unsupervised)	2500 B H P
Maximum boiler horsepower requiring licensed power engineer (unsupervised)	500 B H P
Refrigeration license (unsupervised)	1000 tons

First Class Engineer	
Criterion	Qualification
Education required	High school, technical school, job experience
Experience required	6 years minimum
Examination required	Oral, written, practical
Minimum time in previous grade	2 years
Maximum engine (prime mover) horsepower requiring licensed power engineer (unsupervised)	7500 HP
Maximum boiler horsepower requiring licensed power engineer (unsupervised)	1500 B HP
Refrigeration license (unsupervised)	5000 tons

Chief Engineer	
Criterion	Qualification
Education required	High school, technical school, plant and management experience
Experience required	10 years
Examination required	Oral, written, practical
Minimum time in previous grade	4 years
Maximum engine (prime mover) horsepower requiring licensed power engineer (unsupervised)	Unlimited
Maximum boiler horsepower requiring licensed power engineer (unsupervised)	Unlimited
Refrigeration license (unsupervised)	Unlimited

Examining Engineer	
Criterion	Qualification
Education required	Bachelor's degree or equivalent
Experience required	12 years
Prerequisite	Chief Engineer's license
Examination required	Written

Technical Instructor	
Criterion	Qualification
Education required	Bachelor's degree or equivalent
Experience required	12 years
Prerequisite	Chief Engineer's license
Examination required	Written

Appendix K: NUS Tape Ordering Procedure

To order reproducible video tapes mentioned in this report, submit a Military Interdepartmental Purchase Request (MIPR), DD Form 448. Ensure entries are made in block 5 and block 16. In the description block indicate the tape identification number (i.e., 802-723). Enter a POC and POC phone number in block 8 to allow the Joint Visual Information Activity to clarify or correct requests. The price for each 1/2-in. VHS format tape as of 16 May 94 is \$6.00. Send MIPR's to:

USACVIC/JVIA
ATTN: ASQV-JVIA-T-AS
Bldg 3., Bay 3
11 Midway Road
Tobyhanna Army Depot, PA 18466-5102

POC: Debbie Whitaker, DSN: 795-7438, FAX 795-6106; COMM: 717-894-7438
FAX: 717-894-6106

Prices are subject to change based on costs of blank video tapes. These tapes are available to DOD and DOD government-owned, contractor operated activities only. DOD has been granted a license to reproduce unlimited copies of the video tapes listed in this appendix.

Table K1. NUS Tapes			
Topic	Tape Number	PIN	
Functions of the Power Plant	P-1	802723	DN
Boilers	P-2	802724	DN
Turbine Fundamentals	P-3	802725	DN
Plant Operation	P-4	802726	DN
Number and Number Systems	P-5	802727	DN
Powers, Roots, and Measurements	P-6	802728	DN

Topic	Tape Number	PIN	
Algebra and Formulas	P-7	802729	DN
Algebra and Graphs	P-8	802730	DN
Fundamentals of Math Applications	P-9	802731	DN
Using Formulas	P-10	802732	DN
Graphs, Charts, and Tables	P-11	802733	DN
Power Generation Problems	P-12	802734	DN
Energy Conversion	P-13	802735	DN
Properties and Fluid Flow	P-14	802736	DN
Pressure	P-15	802737	DN
Temperature and Heat	P-16	802738	DN
Water/Steam Properties	P-17	802739	DN
Applications	P-18	802740	DN
Steam Tables	P-19	802741	DN
Plant Performance	P-20	802742	DN
Fluid Flow, Piping, and Piping Auxiliaries	P-21	802743	DN
Pumps and Drives	P-22	802744	DN
Compressors and Fans	P-23	802745	DN
Operation of Plant Auxiliaries	P-24	802746	DN
Reading System Diagrams	P-25	802747	DN
Steam Systems	P-26	802748	DN
Condenser, Circulation Water, and Fire Systems	P-27	802749	DN
Condensate and Feedwater Systems	P-28	802750	DN
Fundamentals of Electricity 1	P-29	802751	DN
Fundamentals of Electricity 2	P-30	802752	DN
Batteries, Generators, and Motors	P-31	802753	DN
Transformers and Control Mechanisms	P-32	802754	DN
Principles of Instrumentation	P-33	802755	DN
Pressure and Flow Measurement	P-34	802756	DN
Level and Temperature Measurement	P-35	802757	DN
Reading Instrumentation of P&Id's	P-36	802758	DN
Chemistry Concepts	P-37	802759	DN
Water Chemistry Fundamentals	P-38	802760	DN

Topic	Tape Number	PIN	
Elementary Water Treatments	P-39	802761	DN
Water Chemistry Applications	P-40	802762	DN
Fuel and Combustion	P-41	802763	DN
Coal Handling Equipment	P-42	802764	DN
Oil and Gas Handling Equipment and Flame Characteristics	P-43	802765	DN
Ash Handling Equipment	P-44	802766	DN
Boiler Fundamentals	P-45	802767	DN
Startup and Shutdown Procedures	P-46	802768	DN
Normal Operation and Boiler Efficiency	P-47	802769	DN
Abnormal Conditions and Emergency Procedures	P-48	802770	DN
Boiler Water Treatment	P-49	802771	DN
Raw Water Treatment	P-50	802772	DN
Ion Exchange	P-51	802773	DN
Cooling Water Treatment	P-52	802774	DN
Turbine Construction and Principles of Operation	P-53	802775	DN
Turbine Valves and Support Systems	P-54	802776	DN
Turbine Control, Instrumentation, and Protection	P-55	802777	DN
Turbine Operation	P-56	802778	DN
Environment	P-57	802779	DN
Water Pollution	P-58	802780	DN
Air Pollution: Particulate	P-59	802781	DN
Air Pollution: Gas	P-60	802782	DN
Sensing, Measuring, and Controlling Elements	P-61	802783	DN
Controllers and Final Control Elements	P-62	802784	DN
Types of Control	P-63	802785	DN
Drum Level and Combustion Control	P-64	802786	DN
Generator Principles	P-65	802787	DN
AC Power	P-66	802788	DN
Generator Auxiliary Systems	P-67	802789	DN
Generator Operation	P-68	802790	DN

Topic	Tape Number	PIN	
Reading Electrical Diagrams	P-69	802791	DN
Three Phase Power	P-70	802792	DN
Unit Transformers, Switchyards, and Substations	P-71	802793	DN
Station Service Systems	P-72	802794	DN
Fundamentals of Plant Protection	P-73	802795	DN
Electrical Protection	P-74	802796	DN
Boiler and Turbine Protection	P-75	802797	DN
Logic Diagrams and Integrated Plant Protection	P-76	802798	DN
Gas Turbine Principles	P-77	802799	DN
Components of Gas Turbine Units	P-78	802800	DN
Gas Turbine Operations and Availability	P-79	802801	DN
Power Generation Diesels	P-80	802802	DN
Air Compressors 1	M-1	802803	DN
Air Compressors 2	M-2	802804	DN
Basic Bearings	M-3	802805	DN
Basic Lubrication	M-4	802806	DN
Rolling Contact Bearings 1	M-5	802807	DN
Rolling Contact Bearings 2	M-6	802808	DN
Sliding Surface Bearings 1	M-7	802809	DN
Sliding Surface Bearings 2	M-8	802810	DN
Boiler Maintenance	M-9	802811	DN
Boiler Tube Repairs	M-10	802812	DN
Boiler Inspection and Cleaning 1	M-11	802813	DN
Boiler Inspection and Cleaning 2	M-12	802814	DN
Refractory Maintenance	M-13	802815	DN
Sootblower Maintenance	M-14	802816	DN
Cutting Tools	M-15	802817	DN
Gaskets, Packing, and Mechanical Seals	M-16	802818	DN
Hand Tools 1	M-17	802819	DN
Hand Tools 2	M-18	802820	DN
Measurement Tools 1	M-19	802821	DN

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